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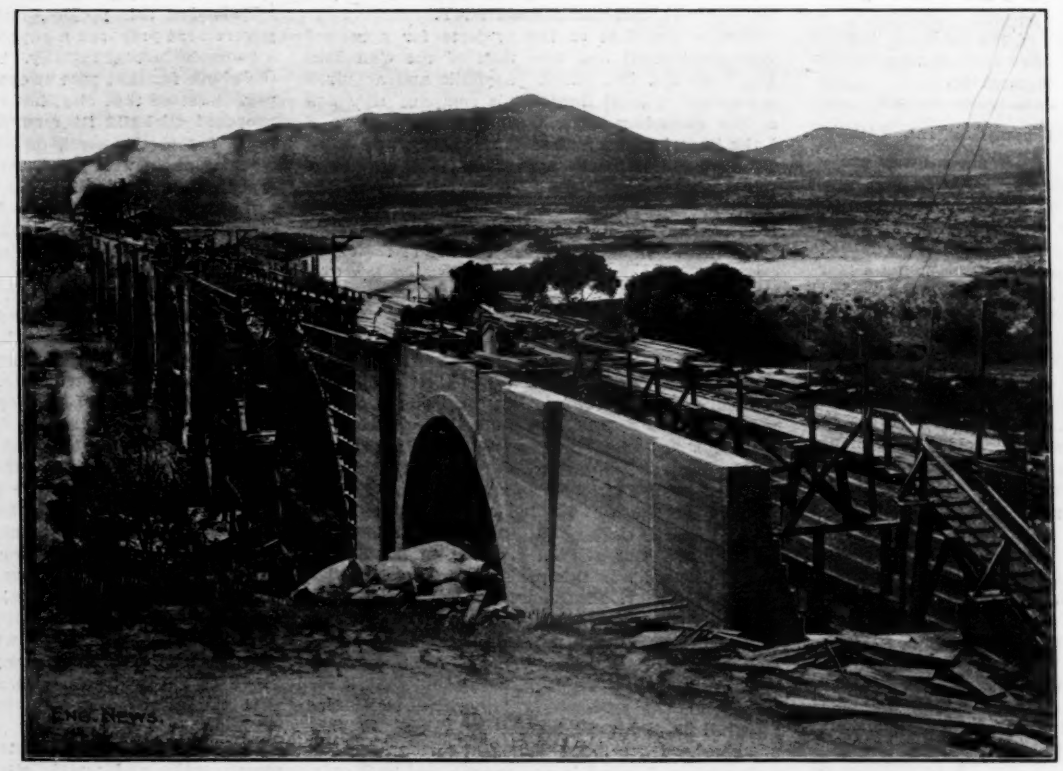
THE CONCRETE VIADUCT NEAR RIVERSIDE, CAL.; SAN PEDRO, LOS ANGELES & SALT LAKE R. R.

By A. C. Ostrom.*

The arched viaduct crossing the Santa Ana River five miles west of Riverside, Cal., on the San Pedro, Los Angeles & Salt Lake R. R., is a concrete structure 984 ft. long, 17 ft. wide, and having an average height of 55 ft. It contains a total of about 14,000 cu. yds. of concrete.

The main arches, eight in number, are circular, having a radius of 43.5 ft., and a rise of 36.9 ft. from the spring to the crown of the arch. The arch ring is 6 ins. wider than the spandrel walls and has an upper radius of 50 ft., being 42 ins. thick at the crown of the arch. The seven stream piers have a footing course 16 × 28 ft., extending from the granite bedrock to a point about 10 ft. below elevation 699.00. Above the footing course to elevation 699.00, water level, the piers are 6 ins. smaller with the corners cut off, making an octagonal form. From elevation 699.00 to elevation 712.50 they have an elliptical form with a 3-in. projection and water table between elevations 711.00 and 712.50. At the latter elevation the spring of the arch begins and the skewback is placed at elevation 723.63. Above elevation 712.50 the piers narrow by a succession of steps and water tables to 9 × 21 ft., and are penetrated vertically by two wells 2.5 × 5 ft., thus saving material and providing a complete drainage system by means of weep holes at the bottom of the wells, at elevation 712.50, and horizontal tunnels at the top of the arch haunch, at elevation 736.00. The outer spandril walls are 3 ft. thick, rising 2.25 ft. above the crown of the arch and surmounted by a 15-in. coping and a 3-ft. parapet wall. There are also two inner spandrel walls running from a point 17.5 ft. from the crown of the arch on each side, and about the same elevation, 732.00, with a slope of 1 to 30 to the piers. These walls are connected by a cross wall 7.5 ft. from the pier and are covered by a 10-in. concrete floor sustaining the ballast which is 3.5 ft. deep at the crown of the arch. The piers are surmounted by a coping supported by brackets or dentils, and a 5-ft. parapet wall forming a refuge bay on each side of the bridge at each pier. The approaches are double retaining walls connecting with the abutment piers by a 38.5-ft. arch of similar construction to that of the larger arches. The retaining walls are relieved by pilasters at either end, the second pilaster acting as the shore pier for the small arch.



THE SANTA ANA CONCRETE VIADUCT NEAR RIVERSIDE, CAL., ON THE SAN PEDRO, LOS ANGELES & SALT LAKE R.R.

H. Hawgood, Chief Engineer; E. B. & A. L. Stone Co., Contractors.

The construction of the bridge was carried out by the E. B. & A. L. Stone Co., of Oakland, Cal. Work was begun the latter part of October, 1902, on the excavations for the foundation of the east abutment pier where the bedrock stands vertical, occupying half the space of the pier and outcropping above the surface in the form of huge boulders. The stream side of the pier extends 22 ft. below the surface of the river bottom. Sheet piling was driven to bedrock and the material to be excavated, sand, gravel and occasional layers of silt, was taken out by means of centrifugal dredge pumps. Seepage from underground sources furnished a sufficient quantity of water to supply the pumps. At the west abutment pier the bedrock sloped at an angle of about 45° toward the bed of the river. This was hewed into horizontal steps, making a firm and secure foundation for the pier. At stream piers, 1 to 6 inclusive, bedrock was reached by the above method with comparatively little difficulty at a varying depth of from 14 to 36 ft. At pier 7, bedrock lies at a depth of 50 ft. below water level and has not yet been reached, though the work is steadily progressing.

Local cement and gravel were used in the foundations, piers, and spandrel walls in the proportions of 1 to 11. It was first intended to utilize the fine gravel in the river bed, but a large deposit of better gravel was discovered above water level in the west bank of the river. It was cheaper to wash this latter than to take the poorer material in the river bottom. This was done by means of a sluice head of water which carried it over a box where the coarser sand and gravel settled, and was conveyed thence to a bunker by means of a bucket elevator, the silt and fine sand being carried away by the water. A trap placed over the sluice fed by 4-horse scrapers prevented the choking of the elevator. A 3-yd. side-dump car and drum hoisting engine were used to bring the sand and gravel from the washer to the top of the bank at the west approach where the mixing plant

*Assistant Engineer, E., B. & A. L. Stone Co., Contractors for Construction of the Viaduct.

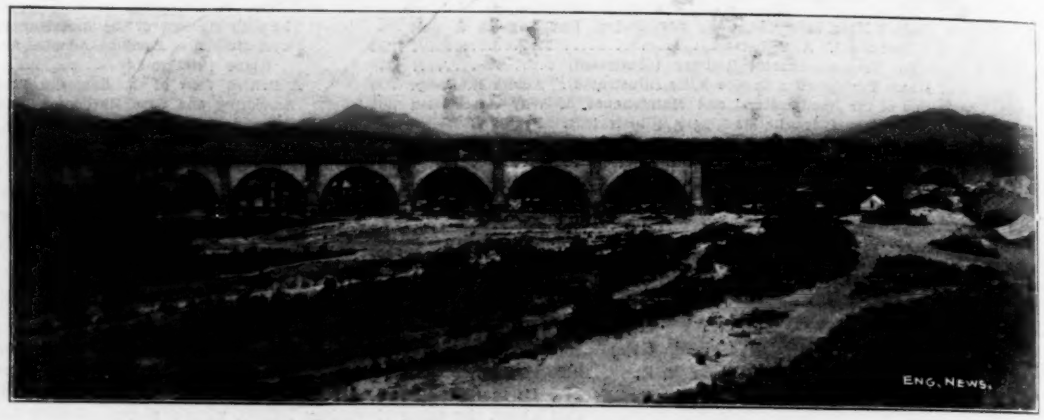
was installed. This plant consisted of bunkers and a battery of three Ransome mixers placed in line, driven by a 25-HP. horizontal engine. A straight trackway ran the entire length of the bridge and a double drum cableway driven by the mixer engine conveyed a train of cars to and from the mixers. The concrete was dumped through chutes from the trackway to the point where it was put in place.

Foreign cement, sand and crushed rock were used in the arch rings in the proportions of 1, 2 and 4½. The arch centering was supported on four bents of four round piles each, driven to bedrock. These were cut off and capped by 12 × 12-in. caps at elevation 724.00; 12 × 12-in. stringers were placed horizontally on these caps. The thrust from the segments was conveyed by 8 × 8-in. struts to horizontal chords which in turn were upheld by wedges placed on the 12 × 12-in. stringers. This form of centering proved very stable and was easily removed after the concrete had set.

Standard Portland cement from the new works at Napa Junction, Cal., was used in the coping and parapet walls, and was found to make a very strong concrete. Tests made proved it superior in quality to the best brands of foreign cement.

Considerable delay was experienced at the outset caused by the long haul of material and equipage, the nearest railway point being five miles from the work. Otherwise, the work has progressed steadily under a force of about 200 men and is now nearing completion.

An interesting feature of the bridge is that no steel nor stone masonry was used in construction it being built entirely of concrete.



SIDE VIEW OF SANTA ANA CONCRETE VIADUCT.

THE NEW CANADIAN TRANSCONTINENTAL RAILWAY.

The largest and most important railway project which has been put forward for some years past is that now under discussion in Canada, which provides for an entirely new transcontinental railway, rivaling the Canadian Pacific Ry. in extent and importance. That this is not a mere promoter's scheme is evidenced by the fact that the government has taken the matter up and proposes to take a hand not only in backing but also in building the road. Briefly stated, the government proposes to build a new line from Moncton, N. B. (on the Intercolonial Ry., giving access to Halifax, N. S., and St. John, N. B.), across the province of New Brunswick to Quebec, and thence to Winnipeg. It will grant a charter to a company to continue the line west from Winnipeg to the Pacific, which company will also operate the entire line, subject to government control. The routes of this line and the Canadian Pacific Ry., as well as those of some rival transcontinental projects, are shown on the accompanying map, Fig. 1.

In 1871, when the treaty was made bringing British Columbia into the Dominion, one of the conditions of the treaty was the construction of a railway to connect this province with the eastern provinces, and this resulted in the construction of the first Canadian transcontinental railway: the Canadian Pacific Ry. A comparison of the population and commerce of the country in 1871, in 1881 (when the uncompleted transcontinental railway project was turned over to the Canadian Pacific Ry. Co. for completion), and at the present time, is tabulated below:

	1871.	1881.	1902.
Population	3,547,000	4,324,000	5,500,000
Revenue	$19,250,000	$29,500,000	$66,500,000
Total trade.... ..	$170,000,000	$203,000,000	$467,000,000
Bank deposits ...	$62,250,000	$99,500,000	$439,000,000

Of course, as to the real necessity of the new line, that can be only a matter of opinion. Its advocates claim that it is desirable now and will be badly needed by the time it is completed. Its opponents, however, claim that the project is far too extensive and costly for the country's needs, and that the lines now built, under construction and sanctioned will be of ample capacity to handle the traffic.

With the remarkable growth and development of Canada and Canadian commerce within the past few years (since the completion of the Canadian Pacific Ry.), and more especially with the settling up of the Northwest territory, there have been at various times demands for new railways into the great wheat regions. These demands have been met in part by the construction of branches and comparatively small independent lines, but they have now culminated in a demand for a new transcontinental railway, extending from ports on the Atlantic to ports on the Pacific, and lying entirely within Canadian territory.

PROJECTS FOR A SECOND TRANSCONTINENTAL RAILWAY.

One of the first of the projects for a second transcontinental line was that of the Canadian Northern Ry. Co., which has built and acquired a number of local lines. This company now has a line extending from Winnipeg eastward to a Lake Superior terminal at Port Arthur, and other lines extending north and west from Winnipeg. It has also a charter for a line as far west as Edmonton, with a view of eventually reaching the coast. During the present year the Canadian Parliament has also extended the life of the charter granted in 1895 to the Trans-Canada Ry. Co., which proposes to build a line on a northern route. Starting from Quebec it would use the Quebec & Lake St. John Ry. to Roberval and Chicoutimi, on the Saguenay River (about 220 miles), and then start across the continent, keeping about 100 miles south of James Bay (Hudson Bay), to which a branch would be built, and passing to the north of Lake Winnipeg, with a branch south to the city of Winnipeg. Keeping north of the Saskatchewan district, it would then head for the Peace River Pass (2,000 ft). or the Yellow-Head Pass (3,800 ft.) through the Rocky Mountains, and have its terminus at Port Simpson on the Pacific Coast. A report on this project made by its chief engineer, Mr. A. E. Doucet, in February, 1903, stated that the grades in the mountains would not exceed 1%, and that no trouble from snow slides would be expected. It is reported that north of Lake Winnipeg there is good agricultural land, and plenty of spruce and tamarack, while the snowfall is light. It is also said that in this neighborhood 200 miles of line have been located with grades of only 4 ft. to the mile, and with only two curves (of 1° each).

In 1902, the Grand Trunk Ry. Co. decided to extend its system into the Northwest territory, and on to the Pacific. It already has a line running north 227 miles from Toronto to North Bay, on the Canadian Pacific Ry., and it was originally proposed to start the new line from North Bay, carrying it to the head of Lake Winnipeg and thence to Port Simpson (or Bute Inlet). This was afterwards modified to a route passing south of the lake and through the city of Winnipeg, and also including an eastern section from North Bay to Quebec. In March, 1903, there was incorporated in Canada (largely by the directors of and persons interested in the Grand Trunk Ry. Co.) a company under the name of the Grand Trunk Pacific Ry. Co., with a capital of $75,000,000 (since reduced to $45,000,000). The act of incorporation authorized the construction of a railway from Quebec to Grayenhurst or North Bay (the northern end of the Grand Trunk Ry. line from Toronto), thence west and northwest to Winnipeg, passing north of Lake Nepigon. Beyond Winnipeg, the line was to pass through or near Battleford, Edmonton and Dunvegan, and by way of either the Peace River or Pine River pass (or "other convenient and practicable pass") through the Rocky Mountains to Port Simpson or Bute Inlet on the Pacific Coast. The construction of branch lines south to Port Arthur, Brandon, Regina and Calgary, and north to Dawson (in the Yukon territory), was also authorized.

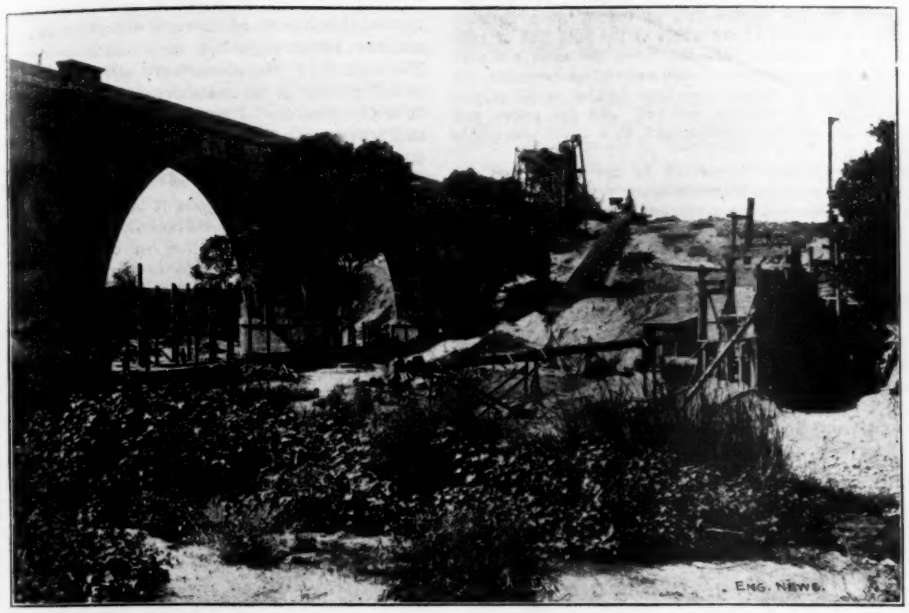
Following this project, however, the Canadian government prepared a supplementary project for a transcontinental railway. This is identical with the above for that part of the line west of Winnipeg. East of that city, however, the government proposed to build its own line to Quebec, on a route far to the north of North Bay. This line would connect with the Temiscamingue & Northern Ry., now being built by the Ontario government from North Bay to the Lake Temiscamingue district, so that Toronto and southern Ontario will be in direct touch with the transcontinental railway. Keeping north of the range known as the "height of land," the line will cut across the province of Quebec to the city of Quebec, where the great cantilever bridge now being built across the St. Lawrence will afford direct communication with the southern part of Quebec and the maritime provinces. At Levis, opposite Quebec, connection could be made with the Intercolonial Ry., which is owned and operated by the government and gives direct access to the Canadian ports of Halifax and St. John. The government project, however, does not include this part of the Intercolonial Ry. in the new transcontinental line, but provides for the construction of an independent and more direct road across New Brunswick to Moncton, on the Intercolonial Ry. While the entire scheme has, of course, encountered opposition, it is this part of the line which has been most severely attacked, since many of those who approve of a new transcontinental railway believe that the existing government line should be utilized.

The project has been debated in Parliament for some months, and certain alternative routes were suggested, utilizing existing lines. One of these alternatives included the use of the Intercolonial Ry. from Halifax to Montreal, with an extension to Coteau to connect with the Canada Atlantic Ry., which would be purchased, giving an outlet on Georgian Bay. Then a new line would connect the Canada Atlantic Ry. with the Canadian Pacific Ry. at Sudbury, and the government would acquire the latter company's line between Sudbury and Port Arthur, and the lines of both the Canadian Pacific Ry. and the Canadian Northern Ry. from Port Arthur to Winnipeg. This government line would be open to any railway companies wishing to use it. West from Winnipeg the government might aid the Grand Trunk Ry. in building a new line to the coast, or arrangements might be made for completion and joint use of the line now being built by the Canadian North-

ern Ry. It does not appear probable, however, that such a patchwork line would be satisfactory or provide favorable conditions for the economical operation of modern railway traffic.

AGREEMENT WITH THE GRAND TRUNK PACIFIC RY. CO.

A contract or agreement has been made between the Canadian government and the Grand Trunk Pacific Ry. Co. for the construction of the line west of Winnipeg, and for the equipment and operation of the entire line. This agreement contains much interesting information as to the organizing of the work and other details, and we give herewith an abstract, which is of interest as a matter of record:



VIEW AT WEST END OF SANTA ANA VIADUCT, SHOWING GRAVEL WASHING AND CONCRETE MIXING PLANT.

A through line of railway of 4 ft. 8½ ins. gage shall be constructed between the city of Moncton, New Brunswick, and the Pacific Coast at or near Port Simpson, or other port in British Columbia. The Eastern Division shall comprise the portion from Moncton through the central part of New Brunswick and through the Province of Quebec, by the shortest available line to the city of Quebec; then west through the northern part of the Provinces of Quebec and Ontario, and through the Province of Manitoba, to the City of Winnipeg. The Western Division shall comprise the portion between Winnipeg (or some point on the Eastern Division), and the Pacific Coast, extending west through the Province of Manitoba, the Northwest Territories and the Province of British Columbia. The railway shall be constructed wholly upon Canadian territory.

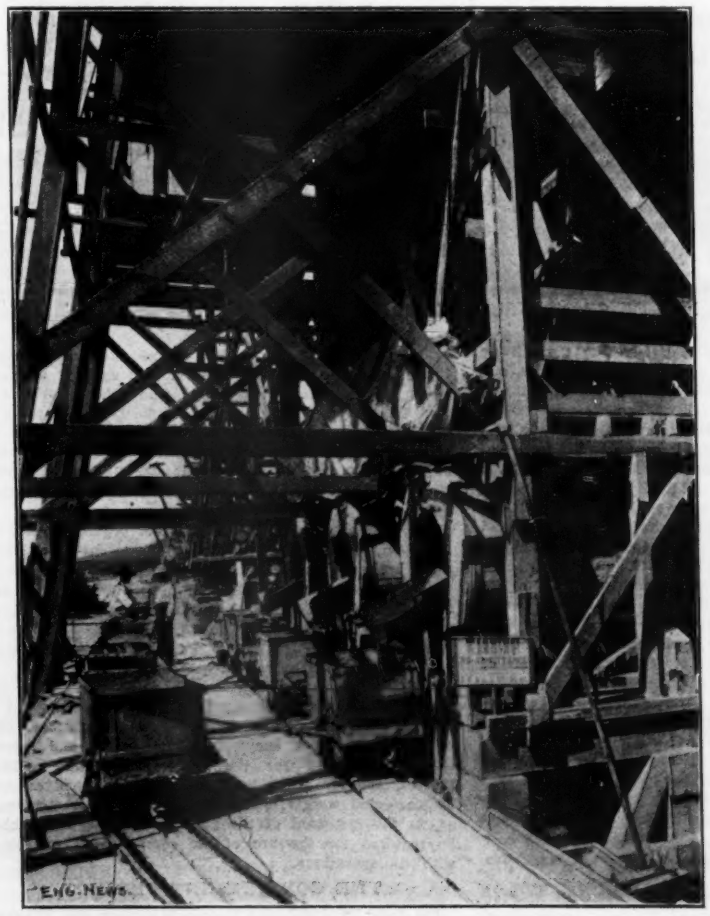
The Western Division is divided into two sections; one extending from the eastern terminus to the eastern limit of the Rocky Mountains (or the Prairie Section); the other extending west from that limit to the western terminus of the division (designated as the Mountain Section). The eastern limit of the Rocky Mountains shall be established after the location of the line, and after actual surveys have determined the profile upon such location, and shall be fixed and agreed upon by the chief engineer of the company and the chief engineer of the government as the result of such surveys, having regard to the physical features of the country, and to the cost of construction, and endeavoring as fairly as possible to determine where the more easy and less expensive work characteristic of prairie construction comes to an end, and the more difficult and expensive work characteristic of mountain construction begins. In case the engineers shall differ, the question shall be determined by the engineers and a third arbitrator, to be chosen by them; and, in the event of their inability to agree on a third arbitrator, the Chief Justice of the Supreme Court of Canada may appoint the third arbitrator, and the decision of the majority shall be final.

The Eastern Division shall be constructed by, and at the expense of, the government, upon such location and according to such plans and specifications as it shall determine, having due regard to directness, easy gradients and favorable curves.

The company agrees to construct, maintain and operate the Western Division, and to take a lease of, maintain and operate the Eastern Division.

In order to insure, for the protection of the company as lessees of the Eastern Division, the economical construction thereof, it is hereby agreed that the specifications for construction shall be submitted to, and approved of by, the company before the commencement of the work, and that the said work shall be done according to the said specifications and shall be subject to the joint supervision, inspection and acceptance of the chief engineer appointed by the government and the chief engineer of the company. In the event of differences as to the specifications, or in case the engineers shall differ as to the work, the questions in dispute shall be determined by the engineers and a third arbitrator, to be chosen in the manner provided above.

The construction of the Eastern Division shall be commenced so soon as the government has made the surveys and plans and determined upon the location thereof, and shall be completed with all reasonable despatch.



VIEW OF CONCRETE MIXING PLANT.

The Western Division shall be constructed by and at the cost of the company, according to plans and specifications to be approved by the government.

The work of locating and constructing the Western Division shall be commenced forthwith after the ratification of this agreement by the Parliament of Canada, shall proceed with the utmost despatch, and shall be completed within five years from Dec. 1, 1903.

The company shall lay out, construct and equip the Western Division to a standard not inferior to the main line of the Grand Trunk Ry., between Montreal and Toronto, so far as may be practicable in the case of a newly constructed line of railway, but this shall not be held to oblige the company to construct a double track railway.

The company shall within 30 days after the passing of the Act confirming this agreement and of the Act incorporating the company, deposit with the government $5,000,000 in cash or approved government securities., as security for the construction of the Western Division and for the first equipment of the whole line of railway. The government shall pay interest at the rate of 3% per annum on any cash so deposited, and shall, from time to time as received, pay over to the company any interest received by it on the securities so deposited. The government shall return the deposit to the company on the completion of the construction of the Western Division and the first equipment of the whole line of railway.

The expression "working expenditure" as applied to the Eastern Division of the railway, shall mean and include all expenses of maintenance of the said division, and of the stations, buildings, works and conveniences and of the rolling and other stock and movable plant used in the working thereof.

The expression "cost of construction," in the case of the Eastern Division, shall mean and include all the cost of material, supplies, wages, services and transportation required for, or entering into, the construction of the division, and all expenditure for right-of-way and other lands required for the purposes of the railway and for terminal facilities, accommodation works and damages and compensation for injuries to lands and for accidents and casualties; cost of engineering, maintenance, repairs and replacement of works and material during construction, and superintendence, bookkeeping, legal expenses, and generally, costs and expenses occasioned by the construction, including interest upon the money expended. The amount of such cost of construction, including the principal and all additions for interest, shall, on completion, be finally determined and settled by the government upon the report of such auditors, accountants, or other officers as may be appointed for that purpose.

In case, after the completion of the Eastern Division, and the taking possession thereof by the company under the lease thereof, or at any time thereafter during the continuance of the said lease, the government shall deem it necessary to expend any sums of money for the improvement of the said Eastern Division, the replacement of structures by others more modern, or otherwise upon capital account of betterments, and not being "working expenditure" payable by the company, the government may expend such sums, and the amount thereof shall be added to the capital of the construction account at the end of the year in which such expenditure takes place, and shall thereafter be considered as part of the cost of construction. No such expenditure shall be entered upon without the consent and approval of the said company.

The cost of construction of the Western Division shall include the like classes of expenditure as in the case of the construction of the Eastern Division, but the amount thereof shall be established by the company to the satisfaction of the government periodically from time to time, and upon the completion thereof in such manner as the government may direct or determine.

When completed the Eastern Division shall be leased to, and operated by, the company for the period of 50 years, at a rental, payable as follows: For the first seven years the company shall operate it, subject only to payment of "working expenditure" as above defined. For the next 43 years the company shall pay annually to the government, by way of rental a sum equal to 3% per annum upon the cost of construction. If in any one or more of the first three years of the period of 43 years, the net earnings over and above "working expenditure," shall not amount to 3% of the cost of construction, the difference between the net earnings and the rental shall not be payable by the company, but shall be capitalized and form part of the cost of construction, upon the whole amount of which rental is required to be paid at the rate aforesaid, after the first ten years of the said lease, and during the remainder of the said term.

If, upon the termination of the lease, the government shall determine not to undertake the operation of the Eastern Division, the company (provided the terms offered by it are as favorable to the government as those offered by any other railway company) shall have the right to an extension or renewal of the said lease for a further period of 50 years, upon such terms as may be agreed upon.

prairie section. The government shall pay the interest upon an amount of bonds equal to the principal of the bonds guaranteed by the government on account of the construction of the mountain section accruing due during the first seven years from the date of the issue of said bonds, and shall not have recourse against the company for any interest so paid. After the expiration of the said period of seven years the company shall be liable to pay the interest.

The company shall purchase all material and supplies required for the construction of the Western Division and the equipment of the whole of the said line of railway from Canadian producers, when the same are produced in Canada and when such material and supplies can be purchased in desired quantities and of equal quality suitable for the purpose required, and for prices and upon terms equally advantageous with those procurable elsewhere.

The aid provided is granted by the government for the express purpose of encouraging the development of Canadian trade and the transportation of goods through Canadian channels. The company accepts the aid on these conditions, and agrees that all freight originating on the line of the railway, or its branches, not specifically routed otherwise by the shipper, shall, when destined for points in Canada, be carried entirely on Canadian territory, or between Canadian inland ports, and that the through rate on export traffic from the point of origin to the point of destination shall at no time be greater via Canadian ports than via United States ports, and that all such traffic, not specifically routed otherwise by the shipper, shall be carried to Canadian ocean ports.

The company shall arrange for and provide, either by purchase, charter or otherwise, shipping connections upon both the Atlantic and Pacific oceans, sufficient in tonnage and in number of sailings to take care of and transport all its traffic, both inward and outward, at such ocean ports within Canada, upon the said line of railway, or upon the line of the Intercolonial Railway, as may be agreed upon from time to time.

The government shall procure to be granted to the company such lands as may be required for the right of way of the Western Division, and for all stations, station grounds, work shops, buildings, yards and appurtenances required for the construction and working thereof, and also such lands fronting upon and covered by navigable waters touched by the line of the railway as, in the judgment of the government, may reasonably be required for the use of the company in connection with its operations.

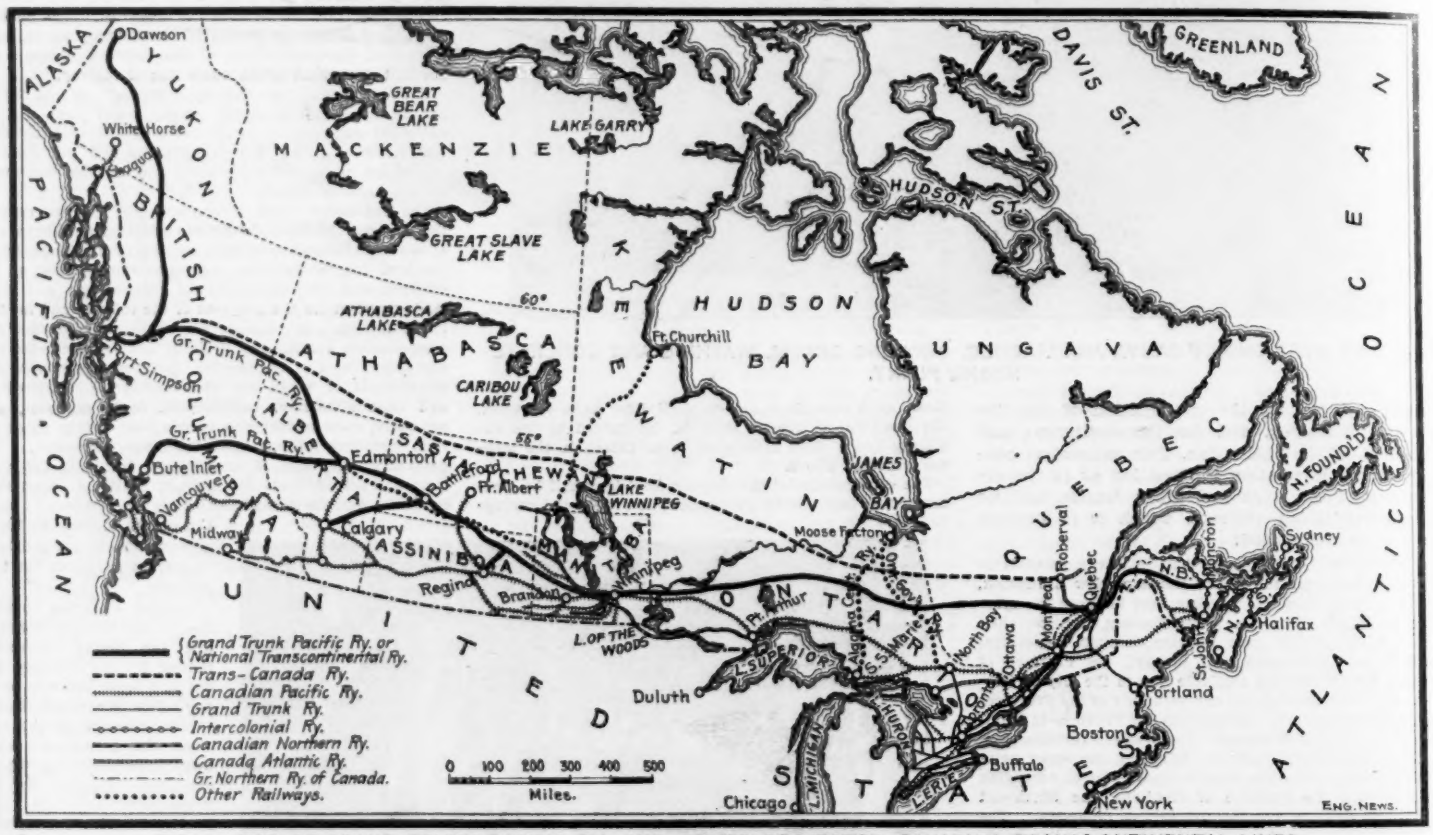


FIG. 1. MAP OF GRAND TRUNK PACIFIC RY. AND OTHER PROJECTED CANADIAN TRANSCONTINENTAL LINES.

The company shall equip both divisions of the railway with modern and complete rolling stock suitable and amply sufficient for efficient operation and the handling of all classes of traffic to the satisfaction of the government, and the first equipment for the completed road shall be of the value of at least $20,000,000, of which not less than $5,000,000 worth shall be supplied for the operation of the Eastern Division of the said railway.

The capital stock of the comapny shall be $45,000,000, of which not more than $20,000,000 shall be preferred and not less than $25,000,000 common stock. The company undertakes that the Grand Trunk Ry. Co., of Canada, shall acquire and take the said common stock to the amount of $25,000,000 except shares held by directors (not exceeding 1,000 shares), and shall hold the same during the term of the said lease, and so long as any of the bonds guaranteed by the government under the terms of this agreement shall remain outstanding unpaid.

For the purpose of aiding the company in the construction of the Western Division, the government shall guarantee payment of the principal and interest of an issue of 3% bonds to be made by the company for a principal amount equal to 75% of the cost of construction. But such principal amount shall not, in any case, exceed $13,000 per mile for the prairie section, nor $30,000 per mile for the mountain section, although 75% of such cost of construction may have exceeded the said respective sums per mile.

The company shall pay the interest upon an amount of bonds equal to the principal of the bonds guaranteed by the government on account of the construction of the

THE GOVERNMENT PROJECT.

On July 30, 1903, the Prime Minister, Sir Wilfrid Laurier, introduced in the House of Commons, at Ottawa, an act for the construction of a "National Transcontinental Railway." The first part of this bill provided for the construction by the government of the Eastern Section, or that portion of the line lying east of Winnipeg, which would afterwards be leased to the Grand Trunk Pacific Ry. for operation. The second part provided for the ratification of the contract already quoted. The government has determined upon the construction of this line in advance of definite surveys, the railway being regarded as a national necessity. The engineers, therefore, have not to consider the practicability or advisability of building the line. It is for them to "either find or make a way." In this respect conditions are similar to those of 1851, when the construction of the Intercolonial Railway was decided upon as a political necessity. But under these conditions it is, of course, impossible to make definite statements as to the route or the resources of the line, or to make any but the most general estimate as to cost.

The act provides that the Eastern Division, extending from Moncton, N. B., to Winnipeg, Man., shall be constructed by or for the government; and that its construction and management (until leased to the above company) shall be under the control of a Transcontinental Railway Commission, to be composed of three members, appointed by the governor. This commission would have all the rights and powers conferred upon a railway company under the Railway Act, and on the completion of plans and specifications could let contracts for construction after the work had been duly advertised. A contract for $10,000 or over would require the sanction of the governor. The purpose of the government in building and owning this section is to keep control of the outlet for grain from the Northwest.

The Western Division, from Winnipeg to Port Simpson, is to be built by the Grand Trunk Pacific Ry. Co., which company is also to equip and operate the entire line, paying a rental of 3% per annum on the cost of construction for the operation of the government division. The reason for turning over to a company the construction of the Western Division is that this will be largely a line for developing a new region and especially in the development of a foreign trade. This will necessitate the construction of harbor and terminal

works, warehouses, grain elevators, the operation of steamship lines, etc., and it was not thought advisable for the government to undertake these various enterprises. The opposition, however, have pointed out that the government in 1900 spent large sums of money in building elevators and wharves at St. John, and that it has undertaken other matters incidental to, but not directly connected with, the operations of its railways.

The contract between the government and the Grand Trunk Pacific Ry. Co. provides that the capital stock shall be $45,000,000 ($20,000,000 preferred and $25,000,000 common stock), and further provides that the whole of the common stock shall be acquired by the older Grand Trunk Ry. Co., thereby ensuring that the new line will be backed by an old and established railway company. The incorporators of the new company include the president, general manager and some of the directors of the older company. On the portion of the line to be built by the company, the government will guarantee the company's bonds to the extent of 75% of the cost of the road. This liability, however, is not to exceed $13,000 per mile for the prairie section, or $30,000 per mile for the mountain section. It will also pay the interest on the bonds for the mountain section for seven years, while the company will pay the interest on the bonds for the prairie section. Taking the length of the mountain section at 600 miles, at $30,000 per mile, the interest at 3½% for seven years would be $3,780,000. The remaining 25% of the cost will be obtained by an issue of bonds to be guaranteed by the Grand Trunk Ry. Co.

The Grand Trunk Pacific Ry. Co. is to provide motive power and rolling stock equipment to the value of $20,000,000, of which at least $5,000,000 worth is to be for the eastern (government) division of the line. As to the character of construction of the western (company) division, the contract requires that it shall be built to a standard not inferior to that of the main line of the Grand Trunk Ry. between Montreal and Toronto, except that a double track will not be required. At the expiration of 50 years the road is to become the property of the government.

The Eastern Division, to be built by the government, will be leased by the company at a rental of 3% per annum on the cost of construction, except that no rent will be required for the first seven years. On this division, the specifications for construction are to be subject to the approval of the company's engineers, so as to ensure economical work. The company is required to buy in Canada all of its supplies that can be obtained within the country, and must make a deposit in cash or government securities as a guarantee for the construction of the western division and the equipment of the entire line. The line from Winnipeg to Port Simpson (including approximately 1,000 miles of prairie and 600 miles of mountain work) is to be completed by the company within five years.

This combination of government ownership and company operation is one of the points of objection to the scheme, but the Minister of the Interior in his speech upon the bill, remarked that experience with the operation of the Intercolonial Ry. did not point to satisfactory results from government operation of the transcontinental line. The Intercolonial Ry. is about 1,510 miles long, and the total capital expenditure up to June, 1902, was $68,310,619. The surpluses since 1876 have aggregated only $445,647; while all the deficits since 1876 (after deducting the surpluses) amount to $5,281,000. These results, however, are said to be due to political causes, rather than to causes legitimately affecting railway operation.

The contract specifies that the company accepts the government aid with the understanding that this is granted for the express purpose of encouraging the development of Canadian trade and transportation. It agrees therefore that all freight originating on the line, and not specifically routed otherwise by the shipper, shall (when destined for points in Canada) be carried entirely on Canadian territory or between Canadian inland ports. The through rate on export traffic from starting point to destination must not be greater by way of Canadian ports than by way of American ports, and such traffic must be carried to Canadian ocean ports, unless specifically routed otherwise. The company further agrees not to encourage transportation by routes other than those provided above. How this will affect the Grand Trunk Ry. terminals at Portland, Me., must remain to be seen. The company is further to arrange and provide shipping connections on the Atlantic and Pacific oceans, sufficient in tonnage and in number of sailings to transport all its traffic at specified Canadian ports.

JOINT USE OF THE NEW RAILWAY.

One of the most singular features of the contract is that which provides for the use of the entire railway as a "common highway" for all railways which may want to use it, the government reserving the right to grant running powers to any railway desiring to use either or both divisions of the line. The Grand Trunk Pacific Ry. Co. is also given running powers over the Intercolonial Ry. It seems doubtful, however, whether satisfactory arrangements could be made for the joint use of such a line by rival railways. If each of several companies desired to use the whole or any long sections of the line it would involve considerable duplication of station, roundhouse and locomotive service. On the other hand, arrangements might be made by which the Grand Trunk Pacific Ry. would furnish motive power for the through trains of other railways.

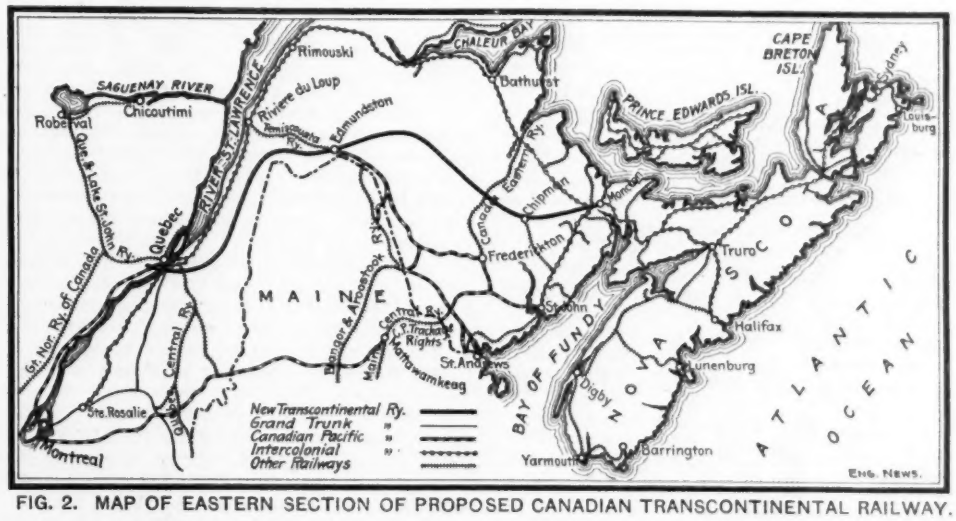


FIG. 2. MAP OF EASTERN SECTION OF PROPOSED CANADIAN TRANSCONTINENTAL RAILWAY.

As an instance of joint operation of a railway, it has been pointed out that the Air Line of the Grand Trunk Ry. from Buffalo to Detroit, 230 miles, has been operated for three or four years by passenger and freight trains of both the Grand Trunk Ry. and Wabash Ry. There is a joint system of dispatching, station agents are paid by each company according to its proportion of the business, and repairs are kept up in the same way. But the joint operation of 230 miles of railway by two companies is a very different matter from the joint operation of 1,000 to 3,000 miles of railway by three or four companies.

GOVERNMENT AID TO THE GRAND TRUNK PACIFIC RY. AND THE CANADIAN PACIFIC RY.

In comparing the above terms granted to the Grand Trunk Pacific Ry. Co. with those granted to the Canadian Pacific Ry. Co. in 1880-81, it is to be noted that the latter was given 25,000,000 acres of land, an exemption from competition, exemption from duties on material, and exemption from taxation. The new company has no land grant, no exemption from either competiton or taxation, and must as far as possible purchase its materials in Canada. Furthermore, the Canadian Pacific Ry. was granted $25,000,000 in cash, and was given works built by the government and said to have cost $35,000,000. The Grand Trunk Pacific Ry. Co. will receive only a cash subsidy of about $13,000,000, as the interest on its bonds, as already noted. On the other hand, however, the government (or the country) will have to pay the cost of the construction of the entire line from Moncton to Winnipeg, which is estimated to cost $50,000,000 to $60,000,000. The old Grand Trunk Ry. Co. has also received government aid. In 1855 it was loaned $15,000,000, but has never paid any interest, and this debt now amounts to $43,000,000, while other assistance brings the total up to some $75,000,000 due to the government.

MONCTON AND QUEBEC SECTION.

While the project has, of course, encountered opposition, it has (as already stated) been most severely attacked in regard to the section lying east of Quebec, for the reason that this section will be in direct competition with the existing Intercolonial Ry., which is owned and operated by the government. It will be of interest to review the conditions of this part of the line, with the aid of the map, Fig. 2. The starting point is at Moncton, the junction of the two lines of the Intercolonial Ry., to Halifax, N. S., and St. John, N. B. The new railway is to run in an approximately diagonal direction across the province of New Brunswick to its northwest corner, keeping as far as possible from the United States boundary, and then striking direct for Quebec.

It will be seen by the map that the province is already surrounded by a loop of railways. From Levis, opposite Quebec, the Intercolonial Ry. follows close to the bank of the St. Lawrence to beyond Rimouski, about 200 miles. It then cuts across the peninsula to the head of Chaleur Bay, and keeps parallel with the coast line to Moncton, whence the main line continues to Halifax and a branch runs southwest to St. John. From St. John, the Canadian Pacific Ry. has a line to Fredericton and along the western boundary of the province to Edmundston, whence the little Temiscouata Railway forms a connecting link with the Intercolonial Ry. at Riviere du Loup, on the St. Lawrence. The grades on the Temiscouata Ry., however, are very unfavorable for heavy traffic. There is also a line of the Canadian Pacific Ry. from St. John to Montreal, but this cuts across the State of Maine, and is not an "all Canadian" route.

In the southern central portion of New Brunswick there are two small independent railways: The Canadian Eastern Ry., 125 miles long, extends northeast from Fredericton (on the Canadian Pacific Ry.) to Loggieville, on Miramichi Bay, crossing the Intercolonial Ry. at Chatham. The Central Ry. of New Brunswick runs north from Norton (on the Moncton-St. John line of the Intercolonial Ry.) to Chipman, 45 miles. It has been suggested that the transcontinental line might strike Chipman and so get a short cut to St. John.

THE BONDING PRIVILEGE.—One of the strong points made by the advocates of this portion of the transcontinental line was the possibility of the American government at some time withdrawing the present bonding privileges granted to American railways. Sir Wilfrid Laurier, in introducing the bill made the following remarks: "From the early days of Canadian railway development we have been forced to make use of

American territory and harbors. The American government granted us the bonding privilege; the privilege of using their harbors for our imports and exports without paying them tolls and custom dues. But this privilege has always been held over our heads by the American authorities as a sword." He then proceeded to enumerate instances where the withdrawal of these privileges has been suggested as a means of bringing Canada to terms or of preventing action which might be unfavorable to American interests. Thus in 1888, when Canada and the United States were disputing over the fisheries treaty, President Cleveland sent a message to Congress suggesting that he be given the power to suspend by proclamation the operation of all laws and regulations permitting the transit of goods in bond across or over the railways of the United States to or from Canada. Similar action was suggested in 1892 by the U. S. Senate Committee on Interstate Commerce, and again in 1893 in a message of President Harrison. It is urged therefore that while friendly relations now exist and are likely to continue, Canada should be independent of this privilege, and to this end should build the new line through Canadian territory, to give a short route between Canadian ports and the interior. The answer made to this is that if the bonding privilege should be abrogated, Canadian traffic would be routed over the Intercolonial Ry. to Halifax, and that the railways have little fear of such action.

The Intercolonial Ry. was projected in 1864, more as a political and military line connecting the ports of Halifax and Quebec (the latter of which is closed in winter) than to develop the interior of the province. For many years it had no good northern terminal, the line ending at Levis, opposite Quebec, and having communication with Montreal by a branch of the Grand Trunk Ry. In 1897, however, a shorter line (the Drummond County Ry.), was built from Levis to Ste. Rosalie (on the Grand Trunk Ry.), 38 miles from Montreal. This was bought by the government and now forms a part of the Intercolonial Ry. It cost $1,000,000, besides $500,000 spent on improvements after the purchase, and in addition the government pays to the Grand Trunk Ry. Co. an annual rental of $140,000 for the use of the Montreal terminal.

The distances from Quebec (Levis) are as follows: Moncton, 488 miles; Halifax, 675 miles; St. John (via Moncton), 577 miles. It is estimated that at least 120 miles can be saved by the new line, so that the distances would be reduced to about 368 miles to Moncton, 555 miles to Halifax and 383 miles to St. John (via Chipman). With lines equally favorable for operation, and with trains at 30 miles an hour, a saving of 120 miles would mean a reduction in time of about four hours. The advocates of the new line say that a very favorable route is obtainable, while its opponents say that a range with an elevation of 2,000 ft. would have to be crossed, and that the line would traverse a difficult country, involving several grades, quite unsuitable for economical operation under modern conditions of traffic. At the present time there seems to be little definite knowledge on this point. The opponents of this part of the line also claim that not more than 50 miles could be saved, and that this would not warrant the expenditure of $12,000,000 or $15,000,000 for the construction of the new line, especially in view of the difficulties of location.

In support of these statements it is pointed out that in 1864 no less than ten different lines across New Brunswick were surveyed for the route of the Intercolonial Ry. by Mr. (now Sir) Sandford Fleming, and that the most direct and favorable line gave a total length of 490 miles, or only 63 miles less than that finally adopted for the present line, which has more favorable operating conditions. His report also stated, however, that next to the route following the United States frontier (and since built upon by the Canadian Pacific Ry.), the central route across New Brunswick would be the best for developing the country and transporting through freight.

But it is very evident that surveys made 30 years ago cannot be taken as a basis for the construction of a railway to be operated under modern conditions, which demand the highest economy in cost of operation. In fact, Sir Sandford Fleming has also been quoted as saying recently that it is not possible to obtain a line suitable for the grain traffic on the route proposed for the new railway. At the same time he suggested the use of the existing line from Edmundston to Fredericton, and then building across to Moncton, as was proposed many years ago.

The objection is of course made that the new line would rob the Intercolonial Ry. of practically all the through traffic, and even with this traffic the present line has never been a financial success. This latter discouraging result, however, is said to be mainly due to political rather than operating conditions. The reply made by the advocates of the line is that by the time the line is built there will be ample traffic for both lines, while the new line will be too far away to affect existing local traffic, but will develop a new traffic of its own by opening up the interior of the province. The opponents, however, strongly maintain that neither the possibility of the loss of the bonding privilege nor the opening of a new and direct route warrant the construction of this rival to the Intercolonial Ry.

In support of the new line it is pointed out that with the growth of traffic and commerce there have been numerous demands for a shorter and more direct line to Canadian ports on the Atlantic. In 1884, Sir Charles Tupper (then Minister of Railways and Canals) advocated the construction of a line connecting Montreal with St. John and Halifax by "the shortest and most practicable route." In 1885, the government introduced a project for such a short line, but cutting across the State of Maine. The opposition, however (then headed by the present Prime Minister, Sir Wilfrid Laurier), demanded that surveys should be made to see if such a line could not be built entirely upon Canadian territory. But the government project prevailed and now forms the Canadian Pacific line from Montreal to St. John. At first it was intended to build east from Mattawamkeag (Me.) through Fredericton to Salisbury (near Moncton), thus giving a direct line to Halifax, but this piece of line has never been built, and the Canadian Pacific Ry. line keeps south of Fredericton and goes only to St. John.

In 1890, the St. Lawrence & Maritime Provinces Ry. Co. was formed to build a line from Edmundston to Moncton, and the engineer who made the surveys located two lines about 209 miles and 199 miles long, which would have reduced the distance between Montreal and Halifax to 749 or 739 miles. It is reported that the project was in the interests of the Grand Trunk Ry., but the scheme fell through, the government refusing to grant permission for the construction of the line because it would compete with the Maine short-line of the Canadian Pacific Ry.

QUEBEC AND WINNIPEG SECTION.

From Quebec to Winnipeg, the distance will be about 1,400 miles. Through the province of Quebec, north of the St. Lawrence River, and extending west to Lake Abitibi, the line will run through a good farming country, the soil of which is chiefly clay, according to the reports of engineers who have explored the district. The district lying between Lake Abitibi and the western boundary of Ontario was explored in 1890 by an engineering expedition under the direction of the Ontario government. Their report showed a great clay belt well adapted for cultivation, well watered, having many falls that could be utilized for water power, and having a climate that presents no obstacle to agricultural settlement. Besides this there are extensive forests of spruce, jack-pine, and poplar, estimated to contain 288,000,000 cords of pulp wood. The pine region does not seem to extend much beyond the "height-of-land," but on the southern side is an area with red and white pine.

It is further stated that surveys made by Sir Sandford Fleming from the head of the Montreal River to Winnipeg, passing north of Lake Nepigon, showed a very favorable line, with grades not exceeding 1%, and very few large bridges. Along the shore of Lake Superior, where the Canadian Pacific Ry. was built, the country is very rough and unfavorable, but becomes much more favorable in the district north of the lake. So much for the favorable aspects of this part of the line. On the other hand, it is said that in looking for a route for the Lake Superior section of the Canadian Pacific Ry. surveys were made from the Ottawa River north of Lake Temiscamingue and Lake Nepigon, along the English River to Selkirk (near Winnipeg). These showed that beyond the "height-of-land" the country consists of swamps and low scrub forests crossed by granite ridges. The projected line would run north of this "height-of-land," and its opponents claim that the country is worthless for development and that the cost of the line would be excessive. These various and conflicting statements must be taken for what they are worth until the route is definitely determined upon and surveyed.

In support of the railway project, and in order to show the character of the country to be traversed by the Quebec and Winnipeg section of the line, the government has issued a compilation from a number of official surveys and reports respecting this region. The distance is divided into twelve sections of approximately 100 miles each, and covering a belt of 75 miles on each side of the proposed line of railway. Practically the entire region is well timbered, largely with spruce, poplar, and tamarack; but there is also birch, balsam and jack-pine, and some red and white pine, cedar, elm, ash, maple, etc. Numerous minerals also occur and may be developed, and water powers exist in most of the divisions. The first four of these divisions are in Quebec, and the other eight are in Ontario. Briefly summarized, the results are as follows:

1, Quebec Division: Rounded hills and valleys, with lakes and rivers everywhere. 2, St. Maurice Division: The country is less hilly as the line approaches the headwaters of the St. Maurice and Rouge rivers, and the hills disappear at the "height-of-land"; plenty of good agricultural land. 3, Upper Gatineau Division: About 100 miles from the mouth of the Gatineau River the country is generally level, with rocky hills and ridges occasionally seen; the soil is a sandy loam. 4, Upper Ottawa Division: Generally flat or undulating plain, forming a part of the Hudson Bay basin; the southern portion is hilly and rocky; the middle portion (traversed by the line) is flat and has easy grades, occasional ridges and hills; there are large areas of dry clay soil around the "height-of-land," and although the southern portion as a whole cannot be said to be suitable for agricultural purposes, still considerable areas of good land exist in many places. 5, Abitibi Division: The whole country northward from the mouth of the Montreal River is a level clay plain, with rocky hills protruding through it here and there. 6, Upper Moose River Division (Algoma): Fine agricultural land, clay and sandy loam, forming part of the great clay basin of the Moose River; the headwaters of the rivers are well timbered, and the country is an undulating, rolling plain, generally sloping towards James Bay. 7, Algoma Division: Generally level plain slightly inclined to the west; easy grades; practically level country; the soil is mostly clay, land low and swampy in places, rolling land, heavily timbered. 8, Long Lake Division: Level and rolling country, hilly and rocky in the southern portion, flat and generally level along the projected line; fine agricultural land in numerous sections. 9, Nepigon Division: In part level and undulating, and part rocky; good agricultural land, clay soil, and clay loam and sandy loam. 10, Lake St. Joseph Division: The region forms part of a low, rocky, well-watered plateau; the relief of the interior is rarely over 50 ft.; the country is generally flat or gently sloping. 11, Lac Seul Division (Rainy River): A level plateau, partly drift-covered, with large areas of swampy country. 12, Lake-of-the-Woods Division: Generally rolling and covered with areas of sand, occasionally forming ridges; lakes and swampy tracts abound; the valley of the Winnipeg River affords an easy route to Winnipeg, towards which the country slopes gently; where soil exists it is light and sandy.

PRAIRIE SECTION.

Of the section lying between Winnipeg and the Rocky Mountains there is little to be said. It is universally admitted that the line would traverse

a rich country that is rapidly being settled up The agricultural resources of the great prairies of the Northwest are well known, and there are extensive grazing lands in the foothills of the Rockies. The opposition to this part of the project is simply a general objection to the entire scheme, on the ground that the railway is not needed, either to develop the country, or to carry the traffic resulting from its development.

ROCKY MOUNTAIN AND PACIFIC SECTION

As to the construction of the Rocky Mountain section of the line, it is reported that an extremely favorable location can be made either through the Peace River valley or the Pine River valley, while the elevations of these two passes are remarkably low. A comparison of these elevations with those of other lines across the Rocky Mountains (as given in an article on "Profiles of Transcontinental Railways," in Engineering News, June 10, 1897), is given below:

Railway.	Point of maximum elevation.	Maximum elevation, ft.
Grand Trunk Pacific	Peace River Pass.	2 000
Grand Trunk Pacific	Pine River Pass.	2 000
Canadian Pacific	Stephen.	5,288
Great Northern	Summit.	5,202
Northern Pacific	Blossburg.	5,550
U. P. and Ore. Ry. & N. Co.	Sherman.	8,247
Union Pac. and Cen. Pac.	Summit.	7,017
Atch., Top. & Santa Fe	Raton.	7,623
Southern Pacific	Paisano.	5,082
Denver & Rio Grande	Near Leadville.	10,433

We quote the following from the speech made by Sir Wilfrid Laurier in introducing the bill:

In 1872, the Canadian government undertook a systematic and scientific exploration of the whole northern region from Lake Abitibi westward to the Pacific Ocean. From the year 1872 to the year 1880 no less than 28 expeditions were organized to visit, explore, and report upon that country. Their reports are all available to us now, and during that time the sum of no less than $5,000,000 was expended for that purpose. Now, one district was specially examined at that time and that was the northern section of the Rocky Mountains. Several passes; all the passes north of the Kicking Horse Pass, were examined and especially the Pine River Pass. Mr. Marcus Smith, Mr. Cambie, Mr. Hunter, Mr. Gordon, Mr. Retske and several others, all engineers of eminence, crossed and recrossed that territory. These explorations show conclusively that the best of all these passes may be found either in the Pine River Pass or in the Peace River Pass.

It is not only a fact that there is a very successful way of crossing the Rocky Mountains either by the Pine River or by the Peace River, but on both these rivers are to be found lands as fertile as the lands of the Red River or the Saskatchewan. The wheat area is fast advancing towards the Saskatchewan River, and in a few years it will pass over to the Peace River and Pine River valleys. And when Manitoba and the Red River and the Saskatchewan River territory have been exhausted for wheat production and have been given to mixed farming, then the Peace River and Pine River territory will become the wheat-producing centers of the world.

In this connection we give also some quotations from the reports mentioned, and it may be noted that the Omineca district referred to by Capt. Butler is a rich gold mining district which is but little worked at present owing to lack of transportation facilities. It is also reported that great coal deposits have been discovered in the Peace River district.

1. But should the Indian Pass at the head of the Pine River prove to be unfit to carry a railway, the Peace River affords a passage vastly superior to any of the known passes lying south of it. It is level throughout its entire course; it has a wide, deep, and navigable river flowing through it; its highest elevation in the main range of the Rocky Mountains is about 1,800 ft.; the average depth of its winter fall of snow is about 3 ft.; by the first week of May this year, the snow (usually deep during the winter) had entirely disappeared from the north shore of the river, and vegetation was already forward in the woods along the mountain base.

But though these are important advantages for this mountain pass, the most important of all remains to be stated. From the western end of the pass to the coast range of mountains, a distance of [illegible] miles across British Columbia, there does not exist one single formidable impediment to a railway. By following the valley of the Parsnip River from "the Forks" to Lake Macleod, the Omineca Range is left to the north, and the rolling plateau land of Stuart's Lake is reached without a single mountain intervening; from thence the valley of the Nacharcole can be attained without the slightest difficulty, and a line of country followed to within 20 miles of the ocean, at the head of Dean's Inlet.

I claim, moreover, for this route that it is shorter than any projected line at present under consideration; that it would develop a land as rich as, if not richer than, any portion of the Saskatchewan territory; that it altogether avoids the tremendous mountain range of southern British Columbia, and the great gorge of the Fraser River; and finally, that along the Narcharcole River there will be found a country admirably suited to settlement, and possessing prairie land of a kind nowhere else to be found in British Columbia.—Captain Butler.

2. Were it necessary or expedient to find a course for the Pacific Railway as far north as the Peace River Pass, a comparatively easy route is offered in this direction. Even at the wildest and most rugged parts of the pass, the mountains are almost invariably fringed by flats or by gentle slopes of varying width. One or two avalanche courses, a few ravines, and occasional projections of rock would form the chief difficulties, which are apparently much less serious than many obstacles that have been overcome on other Canadian railways. At its higher or western extremity the pass is not more than 1,650 ft. above the sea level, and the current of the river, which is very equable, is not more than four or five miles an hour, where it cuts through the mountain range. East of the pass, for 50 miles, till the canyon is reached, the engineering difficulties would probably be not much greater than those presented by an open prairie. But the chief difficulty on this route would be found at the canyon where the river sweeps round the base of a solitary massive hill, known as the Mountain of Rocks, or the Portage Mountains, just above the Hudson's Hope; yet even here, although the work would be heavy, the difficulties would be by no means insuperable.—Mr. Gordon.

3. The Peace River, which is the lowest known pass through the Rocky Mountains, offers a wonderfully favorable line for a railway through that range, and for 60 miles east of its main summit.—Mr. Cambie.

4. There is further the important consideration that, in the place of a bleak sterile country, the line by the Pine River route would traverse an area of remarkable fertility; the fertile belt, or wheat-producing country, extends nearly 300 miles further to the west, before the Rocky Mountains are reached, than by the route over the Yellowhead Pass; a corresponding reduction being made in the breadth of sterile country to be crossed in the Rocky Mountain district.—Mr. Marcus Smith, 1878-79.

Concerning the terminal point at Port Simpson, this port was highly commended by Sir Sandford Fleming (then Mr. Fleming) and Mr. Marcus Smith in their reports of 1878-79. They stated it to be the most eligibly situated harbor for the Western foreign trade. Mr. Smith stated as follows:

Port Simpson may possibly be considered too far north for the terminus of the Canadian Pacific Ry., but it is important that the fact should be borne in mind that by virtue of low altitudes and consequent easy gradients, together with the moderate character of the works required to reach it, this terminal point offers advantages which would enable a Canadian line to defy competition for the trade with China and Japan.

SUMMARY: DISTANCE AND COST.

To summarize the whole matter, we may say in conclusion that the Canadian government is proposing the construction of a great transcontinental railway of which the following are the special features:

First, Construction by the government of a railway from Moncton, N. B., to Quebec and Winnipeg. Second, The construction by the Grand Trunk Pacific Ry. Co. of a railway from Winnipeg to the Pacific Coast at Port Simpson or Bute Inlet, with a branch to Dawson in the Yukon district. Third, Construction of the company's part of the line within five years. Fourth, Equipment and operation of the entire line by the Grand Trunk Pacific Ry. Fifth, The use of the railway as a "common highway" free to all Canadian railways subject to arrangement with the government.

The length of the line will be approximately as follows:

	Miles.
Halifax to Moncton (existing government Int. Ry.)	186
Moncton to Quebec (new government line)	368
Quebec to Winnipeg (new government line)	1,400
Winnipeg to Rocky Mountains (new G. T. P. Ry.)	1,600
Rocky Mts. to Port Simpson (New G. T. P. Ry.)	600
Total distance	3,554
Total distance to be built	3,368

The distance from St. John to Moncton, by the existing line of the Intercolonial Ry., is 89 miles, making a total of 3,457 miles from St. John to Port Simpson, which might be reduced to some extent by the cut-off through Chipman, avoiding Moncton. The distances given are approximations, but it is probable that they would be reduced rather than increased in location. The distances by existing routes from Halifax to Vancouver are as follows: 1. Intercolonial Ry. to Moncton and Montreal, and Canadian Pacific Ry. to Vancouver, 3,743 miles; 2. Intercolonial Ry. to Moncton and St. John, and Canadian Pacific Ry. to Montreal and Vancouver, 3,661 miles.

Without surveys and without a definite knowledge of the character of the country to be traversed, any estimates of cost must be also mere approximations, but we present the following figures as giving some general idea of the vastness of the scheme:

Moncton to Quebec	$12,000,000
Quebec to Winnipeg	38,000,000
Winnipeg to Rocky Mountains	13,000,000
Rocky Mountains to Pacific	18,000,000
Total	$81,000,000

ADVANTAGES OF STEAM TURBINES FOR TEXTIL MILLS.*

By Austin R. Dodge.†

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Within the past six years a great impetus has been given to steam engineering by the rapid development of the turbine as a substitute for reciprocating engines.

All types consist of an opening or nozzle, which may or may not be expanding, which receives the steam and directs it at the proper velocity against the revolving vanes. After the steam is discharged from the first set of vanes, the residual velocity may be utilized to re-evaporate some portion of the moisture inherent to the process of expansion, and enter a second nozzle. This condition insures expansion in straight lines, preventing eddies in the steam, but necessitates a high vane velocity or a multiplicity of parts.

Another method is to receive the jet from the revolving vanes in a stationary set of vanes so arranged as to prevent material loss in velocity at the entrance, and redirect the jet at increased velocity by proper expansion into a second and third set of revolving vanes. This method permits a lower bucket velocity but the tendency for leakage of steam through the clearance spaces is somewhat greater, and the steam jet more irregular the farther it travels in a curved path from one direct guiding nozzle before reaching another. The buckets revolving nearest the nozzle therefore show the highest efficiency.

With an increased number of stages, the velocity at the end of the nozzle is reduced, as the expansion is less, and a smaller number of wheels per nozzle is necessary to abstract the velocity, reducing the losses mentioned.

The efficiency of action depends largely on the relative velocities of the steam jet and the moving vanes, and the energy required to rotate these vanes under the existing conditions of steam density and moisture.

One of the earliest efficient turbines of practical form was brought out by De Laval, and consists of a single combination of nozzles and a wheel attached to the shaft, carrying the vanes on its periphery. The transformation of pressure into velocity in the nozzle, is complex but highly efficient. The steam at the area of smallest cross section, called the throat, always has a pressure about 58% of the initial and a velocity of 1,500 ft. per second, unless reduced by a higher back pressure at the discharge end of the nozzle. If a greater velocity is desired, the cross section at the throat is not changed, but the area of nozzle discharge is increased. We have, therefore, a means of obtaining any desired velocity entering the vanes by throttling the nozzle end pressure, if less than 1,500 ft. is desired, and by nozzle expansion if a greater velocity is essential.

As the specific volume of steam expanding adiabatically increases in greater proportion than the cross section of the nozzle, the velocity increases rapidly. In the De Laval type, it is necessary to fully expand the steam before it enters the vanes, as any residual velocity leaving them is not available for work. A high velocity of the moving vanes is therefore essential.

As the angles of entrance and discharge are the same, and as the wheel rotates in a medium which has everywhere the same pressure, there is no troublesome end thrust as in some types and a minimum of friction due to water of condensation, as there is considerable space between the wheel and the surrounding shell.

An initial pressure of 150 lbs. will give a jet velocity of about 4,000 ft. per second, if expanded to 28 ins. vacuum. The vanes must therefore rotate at a speed of about 2,000 ft. per second to abstract the maximum energy, a speed limited by the strength of material. About 1,200 ft. per second is realized in practice, therefore this type is better adapted for a smaller range between initial and final pressures. A peripheral speed of 1,200 ft. per second with this form of wheel necessitates the use of a flexible shaft and special gearing.

The Parsons machine was brought out shortly before the De Laval and has much lower velocities of steam and vanes, and the process of transforming pressure into work must be repeated many times, entailing a large num-

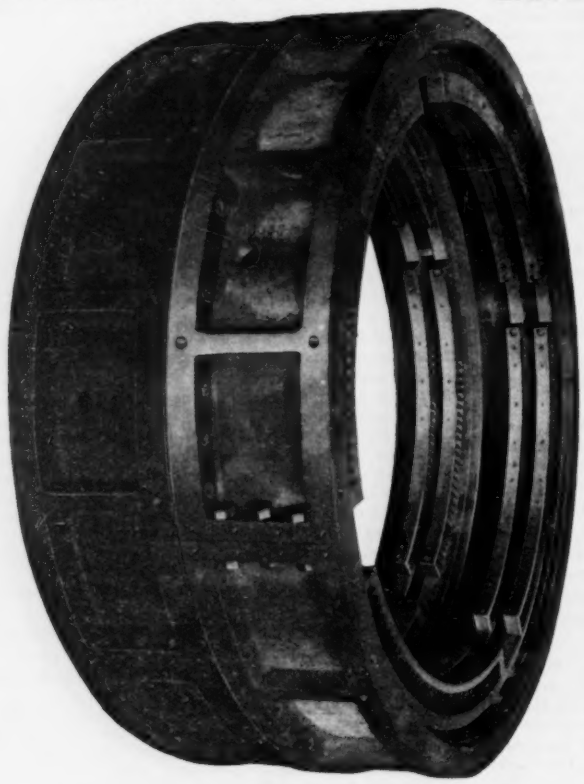
*Condensed from a paper read at the semi-annual meeting of the New England Cotton Manufacturers' Association.

†Schenectady, N. Y.

ber of successive revolving rows of vanes with stationary rows of vanes between each. As there is considerable drop in steam pressure between the entering and discharging sides of the revolving vanes, owing to small clearances, an unbalanced pressure acts on the vanes, resulting in a serious end thrust which is reduced by making the drum carrying the vanes of small diameter, thereby increasing the revolutions per minute and the difficulties of generator design, as gearing is not used.

Many of the vanes must therefore rotate in steam of high density and there is considerable brake action between vanes and outer shell due to water of condensation. Both of these losses are reduced by superheat. The large number of vanes, about 31,000 in a 300 KW. set, are inserted by hand and the longer ones held at the outer end by supporting wires to which the vanes are soldered.

The Rateau type is similar to the De Laval, except that the combination of nozzles and single wheel is repeated



Stationary Rings for Second Stage of Expansion; Curtis Steam Turbine.

several times, with less expansion during each process than in the earlier turbines. A space is given for the steam discharged from the revolving vanes to utilize its energy in the form of velocity by evaporating part of the moisture, and start the process of fractional abstraction anew in the following nozzle. A single wheel per nozzle, or group of nozzles affords a minimum change in the direction of the steam jet at high velocity and shortens its opportunity to diverge before a following nozzle again brings it into line.

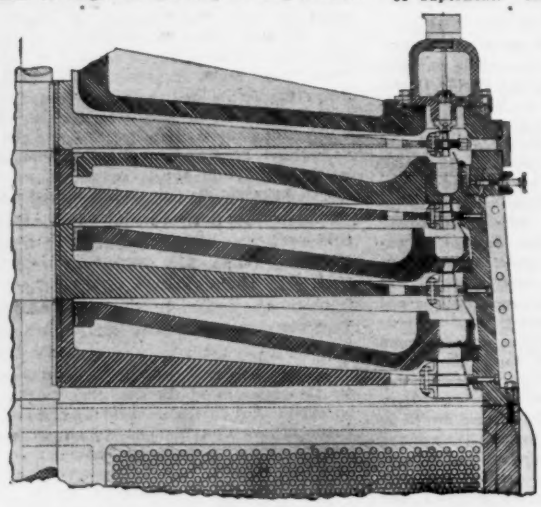
The cylindrical clearance space between each intermediate nozzle and revolving element is near the shaft where the clearance can be made a minimum. This greatly increases the area of stationary nozzle surface near the revolving elements and adds to the loss through friction. As in the Parsons type, many of the wheels revolve in steam of high density and the friction caused by water of condensation is considerable. A print of this turbine recently published shows 25 wheels and 25 sets of directing nozzles. Proper adjustment of these 25 clearances with variable shaft temperatures, leaves much to be desired as to simplicity.

Still another type is that brought out in this country by Mr. Charles G. Curtis, which in addition to nozzles delivering steam at high velocity to a single wheel has also stationary vanes which redirect the steam discharged at considerable velocity from the first wheel, due to the relatively low bucket speed, into the second wheel. The velocity of the jet leaving the nozzle is about 2,000 ft. per second, about half the velocity of the De Laval under the same conditions of exhaust pressure, while the peripheral speed of the vanes in the Curtis is proportionally much less, about 400 ft. per second instead of 1,200 ft. per second. By this process of fractional abstraction the speed of revolving vanes need not be excessive to secure maximum economy, in other words to bring the direction of the jet discharged from the last set of vanes parallel to the shaft. With this high steam velocity only a minimum of revolving vanes are necessary, and they rotate in steam which has a lower density, due to the considerable drop in pressure from one stage to the next. There is a large clearance between the outer wall of revolving vanes and the shell, reducing friction due to water of condensation. End thrust is eliminated, as there is abundant opportunity for the pressure to equalize on each side of the revolving disks, and the entrance and discharge angles of the vanes are the same.

The Curtis type differs from those already described in a number of ways. In the larger sizes the shaft is vertical and floats on oil under sufficient pressure to balance the weight of the revolving element, which rises a few thousandths of an inch until the clearance is sufficient to permit the discharge of the oil delivered at the center of the supporting block.

That there is no end thrust in this turbine is shown by the fact that the oil pressure necessary to float the revolving element does not change under any condition of load. This vertical arrangement affords great compactness and greater uniformity of expansion due to heat.

The clearances between stationary and moving parts have proven thoroughly commercial, as shown in several months' operation of vertical 500 KW. units. In cases in which the oil pressure has failed in the vertical type of this unit during the use of a temporary belt driven oil pump, there has been no damage to the revolving or stationary vanes. Any contact which may occur is due to the lifting of the revolving element owing to formation of ridges on the step bearing surface.



Part Vertical Section of Curtis Steam Turbine.

The weight of the revolving element therefore tends to neutralize any tendency to injury. As the vanes are less in width than the metal from which they are cut, nothing more serious happens than a polishing of the solid part of the wheels. Even the step bearing block can be faced off and used again. When using the standard direct-drive oil pump failure of oil supply to the step bearing is highly improbable.

The 500-KW. type has two sets of nozzles, each delivering steam to a set of three revolving disks, carrying the vanes, which are machined from the solid disk. Governing is effected by operating a series of valves which control the admission of steam to the nozzles on the first stage. This insures a constant velocity in the first stage nozzles, while the pressure in the first stage diminishes with the steam flow until at no load it is nearly equal to the vacuum in the second stage, a desirable condition, as it reduces the density of the steam in which the first stage wheels rotate, and renders unnecessary the adjustment of the valve controlling the second stage nozzles.

The following table embodying approximately the velocities of turbines of 300 KW. to 500 KW capacity will aid in this comparison:

Type.	Rows of rotating bkt rings.	Steam velocity ft. per sec.	R. P. M.	Peripheral speed.	Buckets.
Parsons	35	400	3,600	200	inserted
Rateau	25	800	2,400	400	inserted
Curtis	8	2,000	1,800	400	solid
De Laval	1	4,000	20,000	1,200	inserted

The amount of capital invested in cotton manufacturing interests has been estimated at over two billion dollars. Let us consider the utility of the steam turbine in increasing the return from this investment.

As to first cost of such an installation, a Curtis turbine requires only 7% of the floor space taken by a horizontal cross-compound engine of the same capacity, and the cost of foundations is in about the same proportions in favor of the turbine. The weight is from 15% to 25% that of the engine.

There is no wear with a moderate amount of superheat resulting from the action of the steam jet on the vanes, even at a velocity of 2,500 ft. per second, as shown by long continued tests.

One of the great advantages of a turbine is due to the entire absence of internal lubrication. Consequently the condensed steam can be returned to the boilers, saving the cost of oil and water, often 10% the cost of fuel. As no boiler scale is formed while using the same feed water continuously, tube cleaning is unnecessary and the boilers are maintained at the highest efficiency without withdrawal from service.

It is estimated that the saving in attendance charges will average 25% on the entire station pay roll. A turbine having but one moving part requires no adjustment, unlike a reciprocating engine with a large number of moving parts, which must be carefully inspected at frequent intervals by a skilled engineer. The economy therefore remains constant, which is not true of a reciprocating engine.

One of the principal requirements of textile mills is uniform speed. A turbine has a large amount of stored energy in its revolving parts and is therefore well adapted for work requiring close regulation. The variation in speed of the larger units is within 2%, when the load is varied from no load to full load. Fly-wheels are not required on any type, as the driving force is always transmitted without angular variation; a desirable condition when generators are operated in parallel.

The absence of internal lubrication permits a high degree of superheat. The superheat of the turbine has been raised to 250° F. without increasing the temperature of any part of the revolving wheels or surrounding casing, except the admission valves. The conditions in an engine operating at this high temperature would not be as favorable.

Actual experience in commercial operation has shown that water carried over from the boilers in large quantities does no injury to any part of the turbine, a serious condition when engines are in use.

The first vertical turbine engine to be installed in this country was in an electric central station at Newport, R. I. Comparison with a Corliss cross compound condensing engine of similar capacity under the same conditions of pressure and superheat assuming the engine to have the same full load economy shows that the turbine has a higher economy when running at partial loads and at overloads. The station is arranged for four turbines, two of which have been put in service.

Similar plants have been installed at Scranton, Pa., Dover, N. H., and within the past year orders have increased to such an extent that 200,000 HP. of Curtis turbines are under contract. A 600-KW horizontal unit has been in continuous service at Schenectady for two years, operating for two periods of about four weeks each without a single shut down. A 1,500-KW. Curtis unit is in successful operation at Port Huron, Mich., carrying a mixed load of motor power, railway and lighting. This turbine has the standard clearance of .03 to .05 in. between stationary and moving parts, and can be started cold and brought up to full speed in half an hour. It is easily brought into synchronism with other three-phase

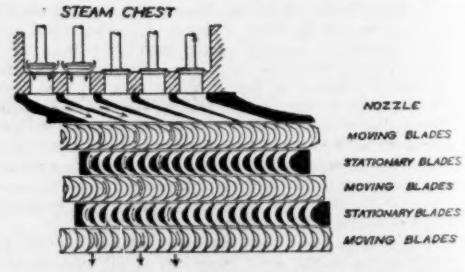


Diagram Illustrating Nozzles and Buckets, in Curtis Steam Turbine.

generators driven by cross-compound engines. A 5,000-KW. Curtis turbine has recently been installed at the Commonwealth station, Chicago, where provision has been made for 14 similar units. This machine, the first of its size, has been operated continuously for several periods of eight hours each on a water rheostat load of 5,000 KW. and will shortly be put in commercial service. On account of water leaks around the condenser tubes, no reliable economy tests have yet been made.

In textile mills the first units to be installed are three

300-KW. Curtis turbines at the Lane Cotton Mills, New Orleans, and two similar units at the Fulton Bag & Cotton Mills, Atlanta, Ga.

ANNUAL CONVENTION OF THE ROADMASTERS' AND MAINTENANCE OF WAY ASSOCIATION.

The 21st annual convention of this Association was held at Kansas City, Mo., Oct. 13 to 15, the headquarters and place of meeting being at the Coates House. The meeting was called to order at 11 a. m., Oct. 13, by the President, Mr. John Doyle. An address of welcome was delivered by the Mayor, Mr. Reed, who pointed out the extent to which large cities are dependent upon railway communication, as shown in Kansas City during the recent heavy floods, when the cutting off of the railways almost led to a famine. He suggested that under conditions such as prevail in the neighborhood of that city, it would be real economy to build bridges and embankments with a view to resisting floods, as the losses due to the destruction of property and the interference with traffic and commerce fall very heavily upon the railways. The mayor's address was briefly responded to by the President, Mr. Doyle, and the Second Vice-President, Mr. Kerwin.

MAINTAINING LINE, SURFACE AND GAGE OF TRACK.

This committee report was presented by Mr. C. Linehan (C., R. I. & P. Ry.). It was very brief, and suggested that the bank or shoulder should be at least 16 ins. below top of rail, so as not to hold water and cause softening of the roadbed. He also advocated tamping the ties solid for only 16 ins. inside the rail, and leaving a 5-ft. shoulder of ballast to hold the track in line (2½ ft. level with top of tie and 2½ ft. for the slope). In respiking rails to gage the report recommended filling the old spike holes with hardwood plugs and driving the new spike in the plug, rather than driving it in the body of the tie.

The discussion opened upon the subject of preventing water from remaining so as to soak into the roadbed. Mr. T. Hickey (Mich. Cen. R. R.) said that in putting in new ballast to raise the track, if the old ballast was good and drained well he would put the new ballast upon it. But otherwise he would clean it out and dress up the roadbed surface at subgrade before depositing the new ballast. The report was so brief and dealt so little with the specific subjects assigned that it was voted to refer it back to the committee. At the same time it was pointed out that a majority of members of the various committees has entirely neglected their duties and had not even replied to letters from their chairmen or from the secretary.

NEW AND IMPROVED APPLIANCES FOR USE IN MAINTENANCE OF WAY.

This report was presented at the afternoon session by Mr. C. Buhrer (L. S. & M. S. Ry.), and an abstract is given below:

The subject is so broad that I have decided to select the following on which to report:

1. RAIL LOADING AND UNLOADING MACHINES.—The American rail loading and unloading machine is a new device. With this machine five men are able to load rails from the ground onto the cars, at the rate of one rail per minute, where, as a rule it takes from 14 to 18 men to load rail by hand. The machine is simple in construction. It is anchored upon a flat car and connected to the train pipe by an ordinary air hose to operate the hoist. The action of the hoist is controlled by a valve, operated by one man on the car upon which the loader is placed. When the car in front of the one upon which the loader is placed is loaded, the machine is rolled back onto the car behind the one upon which it had been stationed, and is then in position to load the next car ahead, and so on until all the cars on the train are loaded. To load rail with this machine it takes one man to operate the machine, two men on top of the car to place the rails, one to release the tongs, and one man on the ground to fasten the tongs on the rail.

2. BALLAST LOADERS.—The Torrey ballast loader has a great deal of merit, as a small force of men can load a good quantity of ballast per day, at low cost, when it would not pay to maintain a steam shovel. This machine will load the highest gondola cars, where these cars could not be loaded cheaply by hand. Where railway companies cannot spare motive power to be used for special gravel trains, with the latest improved ballast cars of the Goodwin, Rodger, and other types of side dump cars so arranged as to rapidly dispose of the material where needed, local freight trains or even through freight trains could pick up the loaded cars at the gravel pit and unload at points needed, much cheaper than a special train could be run, and the first train going in the direction of the gravel pit could return the empty gravel cars to the pit. With a good organization not much time should be lost in this way. Records of the Michigan Central Ry., of the cost of loading ballast with this machine, show a cost of 6.2 to 7.5 cts. per cu. yd.

3. WEED BURNING MACHINE.—A new weed burning car has been built by the Chicago, Milwaukee & St. Paul Ry., which, according to official reports, will, in dry weather, wilt and kill the green vegetation at a speed of four miles per hour, at an expense of $1.35 to $1.50 per mile. As the cost of keeping tracks ballasted with the natural soil, clean from vegetation, is quite expensive when the scurfing and mowing has to be done by hand, this machine is economical for destroying the weeds and grasses on tracks where the vegetation is vigorous and fast.

4. OFFSET OR CONNECTING SPLICES FOR DIFFERENT SECTIONS OF RAILS.—Unsatisfactory results in connecting rails of two different patterns, and numerous battered rail ends, are caused by using imperfect and improperly fitted onset splices, not of the proper strength. The connecting splice made by the Continuous Rail Joint Co., is much stronger than ordinary onset splices, made from angle bars, and with this splice joints of different pattern rails could be maintained much cheaper than with onsets made from ordinary angle bars.

5. ANTI-CREEPING RAIL DEVICES.—The line and gage of track is greatly damaged by the creeping of the track rails, especially on double track where the rail is laid with broken joints. The joint ties are usually carried with the traffic, and are badly slewed, causing a large amount of work to replace the joint ties squarely across the track, and re-gage them to a true gage. It seems almost impossible with the present rail fastening to prevent the rails from creeping. Mr. E. Laas, Roadmaster with the Chicago, Milwaukee & St. Paul Ry., has designed and put in service an anti-creeping device that can be fastened to the rail at any point without drilling the rail.

The discussion opened with a storm of questions as to the details of work with the rail-loading machine, showing that it possessed great interest for the members. It is in use experimentally on many roads, and can be used as an air-hoist or derrick for various kinds of work. Mr. Tratman (Engineering News) described the Ware rail-unloading machine which was illustrated in our issue of Oct. 8, and which also is an adaption of the air-hoist. In regard to the ballast loader (invented by the late Mr. Torrey, Chief Engineer of the Michigan Central R. R.), it was explained by Mr. T. Hickey (M. C. R. R.) that it was specially intended for small work where it is not desirable to use a steam shovel and work train, and where the cars are hauled in freight trains. With six men, from 8 to 10 cars per day can be loaded, each car carrying 30 to 35 cu. yds., and the cost averages 6.2 to 7.5 cts. per cu. yd.

As to "compromise" joints, the discussion showed that Mr. Buhrer had mentioned only one of several devices. The Weber, Atlas and Vulcan joints were mentioned, and Mr. Lahey described a scarf joint, in which the head of the larger rail and the web and base of the smaller rail are cut away to let the head of the latter rest on the web of the former. As to the cast joints, it seemed to be the general opinion that they are unnecessarily heavy and costly. The discussion on the use of anti-creeping devices for rails also brought out different devices in addition to that of Mr. Laas. Mr. Jones (C., B. & Q. Ry.) referred to the use by his road of a short piece of angle bar at the middle of each rail, track being laid with broken joints. This is secured to the rail by one bolt and spiked to the tie. It requires extra drilling of each rail. Mr. Cornell (C. & N. W. Ry.) suggested the very old device of notching or slotting the rail base for the spikes, but it was shown that this would be difficult in manufacture, would weaken the rail, and would not provide for respiking.

An address on the preservation and protection of ties was delivered by Mr. Hermann von Schrenk, of the Forestry Bureau, U. S. Department of Agriculture, and some notes of this we shall give with the abstracts of the two reports on ties.

TRACK DRAINAGE AND TILING.

This report was read by Mr. J. M. Meade, Resident Engineer of the Atchison, Topeka & Santa Fe Ry., and an abstract of it is given below:

The most important factor in track maintenance is perfect drainage; the safety of trains, the saving of rails and ties begin here. The stability of the track depends on a dry foundation, and to have this we must have good side ditches amply large to carry off all the water that will ever come into them. Not only must cuts be ditched, but embankments must be sloped to keep them dry and well drained. A mistake is often made by roadmasters who think that embankments will take care of themselves.

Many cases of rough track on embankment have been known to be caused by poorly drained roadbed. It often happens that when ditching in cuts the material is hauled out on the embankments and left in a rough shape, making the edge of the bank higher than the track, thereby impeding the drainage and making a water trough along the center of the track. This has often been done on important roads, the excuse being that on account of the rush of other work it could not be avoided. This is poor practice and should not be allowed under any circumstances; keep the embankments drained the same as the cuts.

Of late years the use of porous tiling has come largely into use for draining cuts and fills and is becoming more popular all the time. From 4 ins. to 6 ins. seem to be the sizes most generally used—4 ins. on fills and 6 ins. in cuts. In case of wet fills made up of different kinds of material, 4-in. tile has been successfully used in Iowa and Missouri on the A., T. & S. F. Ry., placing the tile at right angles to the track from 15 to 30 ft. apart in a V-shaped box made of two pieces of 1 × 4-in. fence boards, placed where the wet material is encountered. This has given good results, where before it was almost impossible to maintain good track.

In wet and boggy cuts and those of a quicksand nature, where all other efforts to drain them and keep good track have failed, this porous tiling is doing better than anything else that has been tried. A common and successful practice is to dig a trench about 3 ft. deep (on a grade of 6 ins. per 100 ft.). This puts the tile below the frost. The tile is laid on a fence board in the bottom of the ditch to keep its joints and line even; the trench is then filled with cinders which, being porous material, carries the water readily to the tile. This can be done at a cost of about 3 cts. per lin. ft. for labor and 3 cts. per ft. for the 6-in. drain tile, and 1 ct. per ft. for fence boards. Total, 7 cts. per lin. ft.

Many sliding fills have been stopped by building a wide berm at the bottom and filling up the old borrow pit opposite the slide for the length of the weak spot. In the case of sliding hill sides and cuts a very successful plan is to dig trenches straight up the cut 15 or 20 ft. apart and let the water drain into these trenches down into the track ditches. In some cases rock has been put into these trenches, set on edge, with good results.

The question of surface ditches is an important one and should never be overlooked. Nearly every case requires special study; some surface ditches have been known to be detrimental and cause bad land slides, etc., but as a rule they do good work when placed the proper distance back from the cut as circumstances require.

In the discussion, all the speakers united as to the practical value of tile drainage, but there was considerable discussion as to the porosity of so-called porous drain tile. Some of the speakers considered that water enters only at the joints, others were equally positive that it percolates through the tile. One member said that he had found hard red tile to be practically impervious to water, but a yellow tile (which is so soft that it can be cut like chalk with a pocket knife) allows water to pass through freely. For draining a wet piece of railway land, 100 acres, to be rented as a golf ground, Mr. Meade had used glazed pipe, with uncovered joints, and the results have been entirely successful. Mr. Burke (C., M. & S. P. Ry.) has also used glazed tile; this was the same as sewer pipe, with bell ends, the pipe being laid with the bell ends up grade. Mr. Hickey (M. C. R. R.) had frequent trouble from the flooding of the St. Thomas yard until he put in a complete system of main and lateral drains, with a manhole at every switch, the manhole being covered with an iron grating. In wet cuts he has put tile drains 6 ft. deep, under the ends of the ties. Mr. Buhrer (L. S. & M. S. Ry.) has used a similar plan, and has drained the water into the sumps of track tanks. In special cases he has gone as deep as 20 ft. Mr. Meade called attention to the necessity of draining the roadbed on embankments, and to his practice of transverse tile drains for this purpose. He has devised a special boring machine with an auger, which is worked from a pit or trench, cut to the proper depth in the side of the bank.

STEEL, CONCRETE AND WOODEN TIES.

At the morning session of Oct. 14, two reports were presented, one being by the Tie Committee as a whole, and the other a supplementary report by Mr. E. E. R. Tratman (Associate Editor of En-

gineering News), one of the members of the committee. Abstracts of these reports and of the discussion, together with notes of Mr. Von Schrenk's paper, will be given in a later issue. The discussion continued during the afternoon session.

MACHINE DITCHING.

This report consisted simply of letters from two of the committee members, describing their own practice and experience:

We built at our shops at Clinton, Ia., a simple machine constructed on a flat car, under the center of which, projecting at right angles, is a beam adjustable as to distance. From the end of the beam is a chain attached to the open scoop about 7½ ft. long. A small derrick on the flat car, operated with air, handles the scoop, depositing the dirt on the fills at the end of the cuts. This requires a train crew and three laborers to operate it, and can move as much dirt as a crew and 40 men loading on flat cars. We could not make as good a slope as with men, but after the ditch is cut, and dried out, section men can trim it up with very little expense. Machine ditching is much cheaper than hand labor, and in many wet, muddy cuts the machine works successfully where we could not get men to work at any price.—A. L. Mead, C. & N. W. Ry.

A greater part of the road where I am located has a great many heavy cuts and fills which are continually sliding and require constant care. I have used the Hart ditching machine (which is made at our shops in Chicago) with good results. This machine is operated by hand, requiring locomotive crew, conductor, two brakemen and three laborers. This is sufficient force where ditches are very wet. Though I would recommend the use of foreman and six laborers when material is dry. With this force and conditions favorable, ditches can be made to look almost as well as if made by men with shovels. Earth can be handled at an expense of from 8 to 20 cts. per yd., distance hauled governing the expense.

There are some objections to machines of this class on account of difficulty in placing material taken from ditches to advantage on embankments. Owing to the way machine is constructed it is necessary to begin widening embankment at end of cut, continuing out as far as material taken from cut will extend, which in a majority of cases will not reach the part of the embankment where material is most needed; also leaving embankment near end of cut too wide to look well. Great care is necessary in making ditch to avoid cutting slope too square at bottom causing cut to slide. Some difficulty exists on side nearest to track causing ballast to roll down into ditch. This can be overcome by careful handling of machine.

The pneumatic ditching machine manufactured by the American Steel Foundry Co., of Granite City, Ill., has a great many advantages over the Hart machine, being heavier and stronger in every respect. It is operated with an air hoist which is a great improvement over the hand machine. The air hoist controls the filling and unloading of scoop; handling sloper, ditch cleaner, shoulder former, leveler and plow. Very neat work can be done with this machine so far as cleaning ditch is concerned, though the same difficulties are to be overcome as with the Hart machine. The scoop or scraper is 3 × 4 × 9 ft. and will haul out from 4½ to 5 yds. each trip. Earth can be handled for from 6 to 15 cts. per yd. on 5 to 800 ft. haul, conditions favorable. The sloper will work either to or from track and make a fairly good slope to cuts. Slope from track can be made to any angle desired. Material taken from cuts and deposited on embankments can be leveled down to any slope desired. The ditch cleaner is used for cleaning ditches in small cuts, cutting ditch to any desired depth, and depositing material on top of slope and out of cut. Such work can be done very cheaply, requiring only one furrow with plow and one run with ditch cleaner, leaving ditch in good condition.—R. Stanley, C., R. I. & P. Ry.

At the afternoon session there was some discussion as to the financial affairs of the Association, which are not so satisfactory as last year, although the membership has increased. It was proposed to stop printing advance copies of the papers, but it was shown that the expense of this could be materially reduced by printing them in the same size and type as for the Proceedings, and then holding the type. It was also decided later to cease distributing copies of the Proceedings free, as a large number are now sent on request to foreign railways and to educational institutions.

THE USE OF 60-FT. RAILS AT STREET CROSSINGS.

This paper, by Mr. J. A. Lahey (C. T. T. Ry.) referred to the frequency of low rail joints at street and road crossings, and the difficulty of raising and maintaining joints at such places. As a remedy he suggested the use of 60-ft. rails at the crossings; the rolling mills to roll quantities of these at their convenience (say 80-lb. Am. Soc. C. E. section), and railways to order a certain proportion of these when placing orders for rails. Mr. T. Hickey (M. C. Ry.) has got rid of a number of joints at road crossings by cutting the rails so as to lay 30-ft. rails through the crossing, no short piece being less than 12 ft. in length. Mr. Single (L. I. R. R.) doubted the advisability of using 60-ft. rails unless they are used on all the track, on account of the expense. He cuts the rails so as to keep joints out of the crossings or near the sides of the crossings. He also thought that rail joints should not be within 8 ft. of the end of a bridge. Other members, however, thought this would require too much cutting of rails and too many short rails. Mr. McEniry suggested the use of the ordinary short rails (20 to 27 ft.) furnished with all rail orders; these being used more especially for country road crossings where trains run at high speed. Mr. Morrison (Cambria Steel Co.) remarked that to do this would require probably 50% of short rails, while the practice is to deliver 10% of rail orders as short rails. He did not approve of using 60-ft. rails at crossings and 30-ft. rails elsewhere, on account of the difficulty and expense of getting the large rails made.

GENERAL TRACK WORK.

This paper was by Mr. A. Morrison (Cambria Steel Co.), formerly Roadmaster of the Lehigh Valley R. R. An abstract follows:

The want of proper drainage of the roadbed is the prime cause of so much general track work, and when this matter is given proper attention, the general conditions are wonderfully improved. It is not sufficient to have ditches only deep enough to drain the ballast, they should be deep enough to properly drain the sub-grade and if this is done intelligently, the ballast will drain itself.

In the construction of new roads, more care should be given to the forming of the sub-grade. It should be finished so that the water will drain from the center to the ditches; to accomplish this a slope of ½-in. to the foot will be ample. This slope should enter ditches which are not less than 12 ins. lower than the outer edge of the slope. All irregularities of sub-grade should be cut down or filled in as the case may be, so that the finished grade will present a uniform appearance. When the sub-grade has been imperfectly finished, during construction, it should be corrected by the maintenance force, as opportunity presents itself, by sloping off the sub-grade as far in on the track as can be conveniently reached and forming proper ditches. Of course the usual small section gang will admit of little of this work, and it should be done by work trains and properly charged to construction. No road is completed until it is properly drained, cuts giving the slope required for each kind of material and fills widened to a uniform width and parallel to the rail.

One thing in particular which attracted my attention on the British railways, was the perfect system of surface drainage of cuts. This is done by a system of open stone drains, which empty into the ditches. On some roads the stones are whitewashed and as the banks are all beautifully sodded it presents quite an artistic appearance. Of course under such a system slides are unknown. This is a matter that must receive more attention in the future in this country.

The heavy and frequent loads passing over the track demand a ballast that will distribute the load over a large area of the sub-grade. The best ballast is universally acknowledged to be broken stone, and the best stone for ballast is that which will offer the greatest resistance to crushing. The larger sizes of broken stone should be laid next to the sub-grade and stop below bottom of ties, from which point a much finer size of stone should be used. This finer size of stone is necessary for several reasons, particularly to facilitate renewal of ties and aid the tamping of the ties so as to secure a uniform and well-supported surface. With large ballast the first is made very expensive and the latter utterly impossible. It is little wonder that on an average there are only two or three ties to each rail solid up to base of rail. It is little wonder that we have such excessive wave movement ahead of the load with the ties threshing in the ballast, when we ask the trackman to tamp the ties with stone that can only be hammered up against the side of the ties rather than underneath them. The destructive effect of the rail wave movement may be expressed thus: The cost of maintenance is in proportion to the extent of the rail wave movement; as it is more or less, so is the cost of track repairs.

The number of section men per mile of main track, is determined largely by the number of trains passing over the road, and the opportunity for men to work. I have seen cases where it took one man to watch another, while he worked, to prevent him from being run down and killed; and have also seen a condition where rails could be changed without the necessity of sending a flag out for protection.

I have little use for the gardening attempted by a few roads to cover a multitude of sins. This time and money had much better be used in tamping low joints, renewing decayed ties; spiking track to gage and getting the top dressing of ballast under the ties. If the section men then have any time to spare, let them form a neat grass line; but should they have time to form a ballast line by laying stones by hand, you had better reduce that force man's force, than permit wasting the company's money in any such frills. A track well drained, well ballasted, well tied and spiked, well surfaced and lined; with ballast evenly filled out, cuts properly sloped and protected, fences in good repair; scrap picked up and piled at designated places and track kept generally clean, does not require any frills to add to its appearance.

Work trains too frequently consist of a lot of old flat cars, an old box car for a caboose, and a still older engine to pull them. The ideal work train should be equipped to run as second section to any passenger train on the road, so that the men can be taken quickly and safely to and from their work. The more rest the men are given at their homes at night, the better condition they are in to work next day.

Give your men one day in seven to rest and let that day be Sunday. Some of you will say that is impossible, but I have proved it possible, and you can do the same, if you will only try. The company loses money on every man who does not rest one day in seven. It has been tried to work men every day in the week and proved a failure. Let the men spend Sundays with their families at home and you will have better men. It is economy for the company and a kindness to the men.

There was no discussion, but Mr. Morrison remarked in regard to the drainage of sub-grade, that some roads made the center part of the roadbed level, and then sloped the sides toward the ditches. On the Lehigh Valley Ry. he had made the slope continuous from the center of the roadbed to the side ditches.

A paper on "The Use and Abuse of Track Tools," by Mr. J. C. Rockhold (A., T. & S. F. Ry.), was then read in the absence of the author. It described more particularly the carlessness and rough usage which are too often allowed by the foremen, but some members objected to the paper on the ground that it represented exceptional rather than ordinary conditions. Other members, however, expressed very positive opinions that the conditions obtain more or less on every railway.

The last paper was on "The Creeping of Rails," by Mr. F. J. Allen (C., B. & Q. Ry.). He outlined the frequent troubles from creeping and the difficulty of overcoming it, and then proceeded to describe the method in use on his road. This consists in laying the rails with broken joints, angle bars slotted for spikes, and a 5-in. piece of angle bar bolted to the middle of each rail and spiked to the tie.

OFFICERS AND PLACE OF NEXT MEETING.

The officers elected for the ensuing year are as follows: President, John Kerwin (Mo., Kan. & Tex. Ry.), Parsons, Kan.; First Vice-President, C. F. Blue (M. & O. Ry.), St. Louis, Mo.; Second Vice-President, T. S. Cafferty (A., T. & S. F. Ry.), Topeka, Kan.; Secretary and Treasurer, J. C. Rockhold (A., T. & S. F. Ry.), Los Angeles, Cal. The next meeting will be held at St. Louis, Md., in September, 1904.

DIAGRAMS FOR ESTIMATING HYDRAULIC MACHINERY.

By Frank B. Kleinhans.*

In designing the ram cylinders of hydraulic machines the load on the ram and the water-pressure to be used are specified. The water-pressure varies, of course, depending upon the circumstances of the case, but most hydraulic machinery for heavy work is built for a pressure of 1,500 lbs. per sq. in. Assuming this pressure to be used, the two accompanying diagrams give on inspection the main dimensions of cylinder and ram for any given load.

Suppose we have a cylinder as shown in Fig. 1, required to have a capacity of 450 tons. In diagram 1, Fig. 2, find 450 tons on the horizontal axis, and the ordinate to the curve at this point gives the required diameter of cylinder, in this case a little less than 28 ins. Before deciding on the diameter of the ram it must be remembered

*2641 Stanton Ave., Cincinnati, O.

that usually either a counterweight or an opposing hydraulic cylinder is used for the return stroke, and the ram must be made sufficiently larger to allow for the power consumed here. The internal diameter of the cylinder, D_2 in Fig. 1, is made 1 to 2 ins. larger than the diameter of the ram, depending on the size of the ram. This would make D_2 in our example about 30 ins.

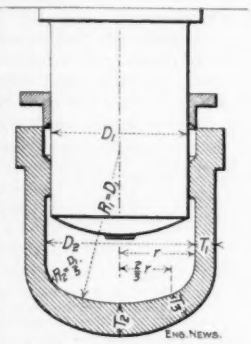


Fig. 1. Sketch of Hydraulic Jack Showing Required Dimensions.

Besides the diameter the main factors affecting the weight and cost of the cylinder, for given stroke, is the thickness of metal in the shell. The three thicknesses, T_1 T_2, and T_3 (Fig. 1) may be determined from Diagram 2, Fig. 2, for either cast-iron at a safe fiber stress of 4,000 lbs. or cast-steel at 10,000 lbs. per sq. in. In Diagram 2 the full lines are for cast-iron, the dotted lines for cast-steel. If in our example the internal diameter of the cylinder is 30 ins., and the cylinder is to be made of cast-steel, we read from Diagram 2 that the required thickness of the side walls (T_1) is 2½ ins., T_2 is 5¾ ins. and T_3 is 4⅞ ins. We can then sketch out the cylinder to scale and estimate its weight and cost.

On very large cylinders and especially if the pressure is high, the metal thickness for cast-iron cylinders becomes very great. Thus, take a cast-iron cylinder 36 ins. in diameter; we find from Diagram 2 (Fig. 2) that the thickness of the metal

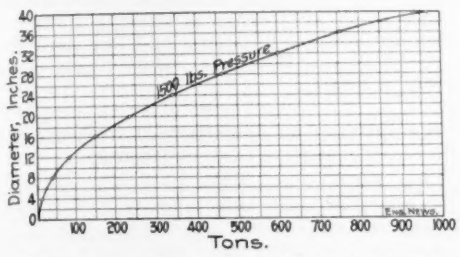


Diagram 1. Required Diameter for Any Load.

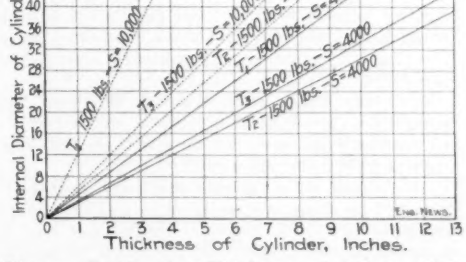

Internal Diameter of Cylinder, Inches.
T1 - 1500 lbs. - S=10,000
T2 - 1500 lbs. - S=10,000
T3 - 1500 lbs. - S=10,000
T1 - 1500 lbs. - S=4000
T2 - 1500 lbs. - S=4000
T3 - 1500 lbs. - S=4000
Thickness of Cylinder, Inches.
Eng. News.

Diagram 2. Required Thickness of Cylinder Walls.

FIG. 2. DIAGRAMS FOR ESTIMATING HYDRAULIC MACHINERY.

at the bottom should be 12 ins. This excessive weight coupled with the fact that cast-iron is always more or less porous with such a large mass of metal makes it inadvisable to use cast-iron for cylinders of this size. A steel cylinder under the same conditions would be 7 ins. thick on the bottom and 3 ins. thick in the side walls.

The curves in Fig. 2 were constructed from the following formulas:

If

T = load on ram, in tons;
P = water pressure in lbs. per sq. in.;
D_1 = diameter of ram, in ins.;
D_2 = diameter of cylinder, in ins.;
T_1, T_2, T_3 = thickness of cylinder walls as in Fig. 1,

then

$$T = \frac{P \pi D_1^2}{2{,}000 \times 4} = .0003927\ P\ D_1^2.$$

$$T_1 = \frac{P D_2}{2(S - P)}.$$

$$T_2 = \frac{D_2}{2}\sqrt{\frac{P}{S}}.$$

$$T_3 = \frac{D_2}{2}\sqrt{\frac{3}{4}\frac{P}{S}}.$$

From these formulas the curves for water-pressures other than 1,500 lbs. per sq. in. may be laid down.

ROCK TRENCH-WORK, BOSTON, MASS.

By Frederick I. Winslow.*

Of the 600 linear miles of public and private streets in the limits of the city of Boston, in not more than 30 miles in length will rock be found nearer than ten feet from the surface of the street. With few exceptions, as where slate or rotten stone is found, the main resistance to explosives is some form of granite, although considerable conglomerate is found in certain sections of the city.

It has been the policy of the city authorities to have all blasting operations done by contract, merely exacting from the contractor a sufficiently heavy bond to cover any reasonable damage, although the sewer department has at the present time a blasting gang in its direct employ.

The use of black powder is now almost wholly limited to blasting outside of trenches or where it is desired to employ the stone for building or other similar purposes, as powder is found to be much less shattering in its effect than the forms of dynamite commonly used. The one explosive which has in this vicinity taken the place of nearly all others is that called "forcite," which consists of 75% nitro-glycerin. The ease of its manipulation, the necessity for a reasonable amount of concussion before detonation, and the possibility of dividing the charge make it an ideal explosive.

Accidents in blasting operations have been extremely rare in this city, and have nearly always been confined to those directly handling the work.

In trench work, with payment for rock removed to neat lines only, the tendency is for the contractor to remove as little rock as possible or to excavate as narrow a trench as he can and yet permit the laying of the pipe or sewer. For house sewers there is usually allowed a width of 3 ft., and for water-pipes below 16 ins. in diameter a width of 2½ ft.

Where the rock reaches the surface of the street, and the excavation is to go, say, 10 ft. in depth, it is customary to make two benches of 5 ft. each, although sometimes one of 10 ft. is made.

The holes are drilled usually about 3 ft. apart, depending somewhat on how the rock acts under explosion, and are staggered a little off center if the rock is homogeneous, and the strata are not inclined. If the strata are inclined, the holes are so directed as to lift with the least resistance; otherwise the holes are drilled vertically.

The drilling is done by hand excepting in the case of a very long trench, where it is done by steam drill. The hand-driller (and the steam-driller as well) employs in going down ten feet, five different sizes of drills, slightly decreasing as he proceeds from a 2½-in. to a 1¼-in. bit.

The depth drilled in one ten-hour day by three men (one holding the drill and two striking) necessarily varies with the hardness of the rock, but eight to ten feet a day is a fair average for hard rock, while a steam drill would make about six times as much, and cost perhaps one-third more. In soft rock 20 ft. is often made by hand. When the hole is finished and cleaned, the forcite cartridge is cut lengthwise so as to make it fill the hole, and after inserting the amount judged to be necessary, varying from one-half to three cartridges, it is well tamped with earth, and the exploder, previously inserted into the cartridge, is made to explode, usually by electricity.

From force accounts kept for the past 15 years, of work consisting of less than 100 cu. yds., the cost of removing rock from the trench and piling it upon the sides is about $3.80 per cu. yd., although contracts vary in price from $2 to $8 per yard.

*Assistant Engineer, City Engineer's Office, Boston, Mass.

FIELD METHODS OF WATER ANALYSIS ADOPTED BY THE UNITED STATES GEOLOGICAL SURVEY.*

One of the interesting features in connection with the work of the Hydrographic Branch of the U. S. Geological Survey is the study of methods of water analysis and their modification for use in the field. During the past year the Hydro-Economic Section, one of the divisions of the Hydrographic Branch, has been making such a study with a view to so modifying methods of analysis that without severely diminishing their accuracy, the operator will be able to carry into the field an outfit containing all the necessary apparatus and reagents.

For the volumetric determinations, such as chlorine, nitrites, carbonates and total hardness the plan contemplates the use of tablets, each containing a known equivalent of the required reagent. These are to be dissolved, one at a time, in the water to be examined, until the end point is reached, the results being approached in a manner exactly similar to laboratory methods where a burette is used with standard solution.

Special apparatus has been perfected for the determination of sulphates, natural turbidity and color, the first two being devised by Daniel D. Jackson, Chemist of the New York Water Department, and the latter by Mr. Allen Hazen, M. Am. Soc. C. E., of New York city.

The whole equipment proposed will be portable, occupying an exceedingly small space, and the determinations can be made with surprising speed. The accuracy of these determinations, as shown by preliminary experiments, is considerably greater than was at first expected. It is believed by those in charge of the work that the mean of a large number of results which can be made throughout any district under investigation within a comparatively short time will be far more representative of the true conditions than a few such determinations made with the usual laboratory methods. Therefore the difficulty which has always been present in the way of time and expense in connection with the chemical survey of drainage areas will be practically removed.

The preparation of these methods has been under the immediate charge of Mr. M. O. Leighton, Hydrographer in Charge, Hydro-Economic Section, who has enlisted the assistance of numerous well-known chemists throughout the United States. As the methods will be of especial use to railroads and other corporations using large quantities of water for boiler purposes, the chemists of a large number of the principal railroads throughout the United States have participated in the work and are at the present time making practical tests of the various methods and comparing them with reference to their accuracy, with the standard methods generally used. Among the railroad officials who have assisted are:

Dr. Charles B. Dudley, Pennsylvania R. R.
J. R. Onderdonk, Baltimore & Ohio R. R.
H. E. Smith, Lake Shore & Michigan Southern R. R.
R. H. Mahon, New York Central & Hudson River R. R.
Robert Job, Pennsylvania & Reading R. R.
C. Newell Sanders, Norfolk & Western Ry.
G. M. Davidson, Chicago & Northwestern Ry.
G. N. Prentiss, Chicago, Milwaukee & St. Paul Ry.
N. F. Harriman, Union Pacific Ry.
W. A. Powers, Santa Fe System.
Dr. John N. Hurty, Cleveland, Cincinnati, Chicago & St. Louis R. R.

Special services have also been rendered by Daniel D. Jackson, Chemist New York Water Department; Mr. Allen Hazen, M. Am. Soc. C. E.; Mr. George C. Whipple, M. Am. Soc. C. E., Director Mt. Prospect Laboratory, Brooklyn, N. Y.

After having been subjected to the scrutiny of the above-named individuals and accepted by them, the practicability of the methods is assured.

*An authorized statement obtained through the courtesy of Mr. F. H. Newell, M. Am. Soc. C. E., Chief Engineer U. S. Geological Survey, Washington, D. C.

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ADVERTISING RATES: 20 cents a line. "Want" and "For Sale" notices, special rates, see page XXIV-XXIX. New copy for standing advertisements should be received one week in advance of publication; new advertisements, Monday morning. The pages containing "Want," "For Sale" and "Proposal" advertisements are held open until Wednesday noon.

The use of motor cars on steam railways to provide an auxiliary local service in certain districts has many times been proposed, and is, on the face of it, a promising idea, affording an additional accommodation on an economical basis, and being apparently likely to prove remunerative by developing local traffic. This matter was discussed at some length in our issue of Feb. 6, 1902, and a number of experiments in this direction made by American railways were also described, but when put to the practical test the results have so far been distinctly unsatisfactory. One of the principal troubles appears to have been in the cars themselves, and more particularly in the boilers of steam cars. All the experiments have been discontinued, largely, no doubt, on account of the failure of the machines, since the general proposition is reasonable and promising. Within the present year this idea has been taken up actively by European railways, and motor cars have been introduced on French and German lines, while some eight or ten English lines have also instituted this class of service. In some cases steam motors are used, while in others oil and gasoline engines supply the motive power. The main object is to develop local traffic, since the growing competition of electric railways has seriously affected this class of traffic on the steam railways, but has also shown the possibility of greatly increasing this traffic by increasing the transportation facilities. As it would not pay to increase the number of stops of the through trains, or to operate a frequent service of short-distance trains the railways are turning to the motor-car idea as an economical means of developing the traffic. Some of the machines are designed by the superintendents of motive power and built at the railway shops, while others are furnished by manufacturers to meet the requirements of the railway companies. An interesting instance of the use of a motor car in railway service in this country is on the Tabor & Northern Ry., in Iowa. This line is 9 miles long, and its motive power equipment has consisted of one locomotive. Recently, however, it has put in service a gasoline motor car to take the place of the engine and train in passenger service. In this case, however, the motor car is a substitute for the locomotive, and not an auxiliary to the latter.

Another use for motor cars in developing traffic for steam railways, is in operating an auxiliary or feeder service on public roads, and several English railways are instituting a service of this kind. In some cases the cars run between country stations and small towns a few miles distant, their schedules being arranged of course to connect with the railway trains. In other cases they are used for tourist or excursion traffic in picturesque districts tributary to the railways. One of the railways in Ireland has also instituted a freight service with traction engines and wagons on the public roads in order to accommodate and develop the traffic of certain districts. The increasing expenses and cost of operation, the relatively small increase in earnings, and the severe competition which the steam railways are beginning to experience from the new electric railways, are all adverse influences which are spurring English railway managements to seek actively for means of improving present conditions.

The rain-making hoax appears to have run its course in this country and it is a long time now since we have heard of any professional "drought-busters" attempting to bring down rain from the skies, although a few years ago there were frequent reports of their work in the West. The absence of long and serious droughts in that locality is probably the chief reason for this; for when a drought continues for a long time, people are ready to grasp at any measure which promises relief, no matter how absurd.

The severe droughts in Australia this year, however, have brought about quite an epidemic of rain-making schemes, which are described in the "Monthly Weather Review."

At Broken Hill, experiments were made by a "Dr." C. De Lacy McCarthy, who was said to be a graduate of Trinity College, Dublin, and who announced that he would "start work on Wednesday and you will have rain by Saturday."

The government of South Australia, the Broken Hill Chamber of Commerce and the Broken Hill water companies, united in bearing the expense of a special train which brought McCarthy with five assistants and apparatus to Broken Hill. McCarthy kept the details of his process secret, but the general operation was described as follows:

> He forces chemical fumes into the air for a great distance which create a vacuum in the fourth, fifth, and sixth strata of air. The center of a heat storm is thus formed and the cold air descends, resulting in a heavy tropical rain. The secret of the chemicals was given him by a man in America. He had improved on the system with the aid of a clever Japanese chemist. He changes his methods to suit varying conditions. It may require 32 hours of continuous work to achieve success. He produced rain in 22 hours in Victoria.

Notwithstanding the haste with which he had been brought, by special train, McCarthy delayed beginning operations for three days, and started at a time when the predictions of the Meteorological Office at Melbourne were for rain within three days. At the time a furious dust storm from the Northwest prevailed, and McCarthy announced that "the vacuum is working still far up." Later the wind changed to the south, and all chance of the predicted rain from the west disappeared, so after working three days the "Dr." gave it up, remarking that "conditions were all against him," an unexpectedly frank recognition of his impotence to really control the weather.

Another scheme for tapping the hypothetical reservoirs of moisture in the upper air was revealed by the Mayor of Broken Hill at a meeting of the Chamber of Commerce on July 20, as follows:

> The formula consists in using sulphuric acid and zinc, the hydrogen set free ascends with aqueous vapor in spiral columns which are hollow when they reach the rain belt in the atmosphere, and the cold air in that region rushes down to the warmer air below.

No process in chemistry is more familiar than the preparation of hydrogen from sulphuric acid and zinc, but the idea that the gas ascends in "hollow-spiral columns" is about as absurd a piece of pseudo-science as anything that Keely ever perpetrated.

Nevertheless the Australians appear to have taken these "hollow spiral columns" seriously, and a committee actually undertook experiments with the "process." It caps the climax to read in the report of this committee that:

> The experiments were not successful, owing to there being rather too much wind to allow the column of gas to ascend perpendicularly.

After reporting these and other absurdities of the Australian drought sufferers, the editor of the "Weather Review" makes the following admirable comment:

> We hope it may prove to be the last occasion on which the rainmakers will attempt to delude the suffering people with their chemicals, their upper vacuum, their dynamite, and their false theories. The time has not yet come when man may plow the atmosphere for rain as he plows the soil for crops. If mines must be worked and towns built in arid regions, let the promoters of these schemes be required to build aqueducts and bore wells sufficient in advance to supply the needed water, not waiting until droughts come and the people die. Every place on this globe has its rainy years and its dry years. Areas of cold and heat, wind and calm, rain and drought appear and move and disappear in irregular succession. We must prepare for them and provide against disaster. We cannot control the weather, but we may control ourselves.

The concrete viaduct on the San Pedro, Los Angeles & Salt Lake R. R., in Southern California, which is described and illustrated in this issue, has been claimed to be the longest concrete viaduct in the world. It has a total length of 984 ft., and its height is about 55 ft. We find on investigation, however, that there is at least one longer viaduct constructed entirely of concrete. It is the Glenfinnen viaduct, on the West Highland Ry., of Scotland, built about four years ago. This structure, 1,248 ft. in length and 100 ft. in height, contains 21 arches of 50-ft. span. The structure was briefly described in our issue of Feb. 9, 1899.

THE OPINIONS OF ENGINEERS ON THE NEW YORK BARGE CANAL PROPOSITION.

The voters of New York are to cast their ballots on Nov. 3 to decide whether the state shall undertake the construction of a 12-ft. canal suitable for 1,000-ton barges, from Lake Erie to the Hudson, with branches to Lake Champlain and Lake Ontario, the funds to be provided by an issue of $101,000,000 in state bonds.

This is by far the largest enterprise ever undertaken by any state of the Union, and it is the most important matter ever submitted to a referendum vote in this country.

That the voters shall cast their ballots with an intelligent understanding of the question at issue is greatly to be desired; yet at the same time the fact is that the question is so difficult and complicated that only an expert, competent to consider it in all its bearings, and from a wholly unprejudiced point of view, is able to form a reliable opinion.

Ought the State of New York to undertake this vast engineering work? Will the benefits, direct and indirect, to the state as a whole be worth the huge sum which it will cost? These are the questions the voter must decide; and manifestly, since he cannot give months of study to the question he must rely on the advice of experts, if he is to vote intelligently.

We are speaking now of the class of voters who really desire to vote intelligently and with the interests of the state at large and not their own personal interest as the motive for their decision. Of course, a heavy vote will be cast against the proposition merely because it will involve increased taxation, and on the other hand an enormous vote of workingmen will be cast for it because it will give employment to labor. That there is a certain danger in placing it within the power of these non-taxpayers to saddle huge burdens upon the property interests of the state must be evident to every candid observer.

Passing the voters who will cast their ballots with their own personal interests as the sole guid-

ing motive, we come to voters who really desire to know the facts in the case and to vote intelligently upon the question. For the benefit of such voters as these we have deemed it worth while to ascertain and publish the opinions of prominent engineers upon the proposed barge canal enterprise.

The proposed canal is an engineering work; from beginning to end, it must be created by engineers Its merits and demerits as an economic transportation route in competition with the railways, the Canadian water routes, existing and prospective, and in comparison with channels of greater or less capacity are all engineering questions.

To that profession, and to that alone, can the public look with reasonable assurance for an unprejudiced and intelligent opinion upon the merits of the barge canal project.

With this in mind we addressed a letter a short time ago to a number of well-known engineers in terms as follows:

Dear Sir: The voters of New York are to cast their ballots at the coming November election to decide whether the state shall undertake the construction of a 12-ft. canal, suitable for 1,000-ton barges, from Lake Erie to the Hudson, with branches to Lakes Champlain and Ontario, the funds to be provided by an issue of $101,000,000 in state bonds.

As the question of economic transportation from the Lakes to the seaboard is almost wholly a question of engineering, it has seemed to us that an expression from members of the profession best qualified by experience and reputation to speak with authority on the subject would be of much interest at this time..

We would respectfully ask, therefore, that you favor us with a reply to the following question, stating briefly your reasons for your opinion.

WHAT ACTION SHOULD THE VOTERS OF NEW YORK TAKE WITH RESPECT TO THE PROPOSED BARGE CANAL?

We need hardly add that it is your free and unbiased opinion which is desired, whether it agrees with the position taken by the editors of this journal or not.

All those to whom we addressed the above letter are prominent and well-known members of the American Society of Civil Engineers. In making up the list we excluded on the one hand engineers connected with the New York canals or who served on the Board of Advisory Engineers for the Barge Canal surveys, and who might conceivably hold that they were in honor bound to defend or at least to refrain from opposing the enterprise on which they had been employed. On the other hand, in deference to the oft-repeated claim that the trunk line railway corporations are opposed to the barge canal project, we omitted from the list engineers connected in any way with these companies or who have been prominently identified with railway work. The names which we selected were those of engineers who by their professional standing and reputation and the character of their experience were qualified to take a broad and unprejudiced view of the subject and render a valuable expert opinion.

We print below the answers received to our letter, including all who expressed an opinion either in favor of or adverse to the proposition. The names attached to these letters are very well known to engineers; but a few notes regarding the professional record of the writers may be of interest.

Mr. Geo. Y. Wisner has a national reputation as a consulting engineer in connection with harbor and waterway works. He was appointed by President McKinley a Member of the United States Board of Engineers on Deep Waterways, under which Board over half a million dollars was expended on surveys and expert investigations with reference to economic water transportation from the Lakes to the Atlantic. He has also served as Consulting Engineer with reference to the proposed Ottawa route from the Lakes to the Atlantic. No higher expert authority on the question now before the State of New York could anywhere be found.

Mr. W. T. Jennings, of Toronto, is one of the best-known engineers of Canada; he is a member of the Institution of Civil Engineers of Great Britain, as well as of the American Society of Civil Engineers, and of the Canadian Society of Civil Engineers. Of the last-named organization he has served as President. Mr. Jennings was City Engineer of Toronto for a long time, but has been in private consulting practice for some years.

Major Wm. H. Bixby ranks as one of the ablest officers in the U. S. Corps of Engineers. He has served on numerous Boards for the investigation of engineering projects, and is at present in charge of the U. S. Engineer office at Detroit.

We deemed it proper to send our circular letter to the engineers at the head of the leading engineering colleges in New York. Replies from several appear below. Mr. Palmer C. Ricketts is Director of the Rensselaer Polytechnic Institute at Troy, Mr. Chas. H. Snow is Dean of the Engineering School of New York University, Mr. Gardner S. Williams is Professor of Hydraulic Engineering at Cornell University and in charge of the famous hydraulic laboratory at that place. Mr. Williams has just been appointed by President Roosevelt a member of an International Commission upon the Regulation of the Levels of the Great Lakes.

Mr. Horace Andrews is a Consulting Engineer of Albany, N. Y., and was for many years City Engineer of Albany. Mr. Geo. W. Rafter is one of the most eminent hydraulic engineers in the profession. His past connection with the New York canals and with the Deep Waterway surveys have made him able to speak with the highest authority on the barge canal proposition.

Mr. Foster Crowell is a well-known Consulting Engineer of New York city, who has been in charge of a large number of important engineering works. Mr. John C. Wait is well known to engineers as the author of treatises on the law of contracts, has had an extended engineering experience, and has had particular opportunities for obtaining knowledge as to actual conditions on the New York State Canals. Mr. Joseph Mayer is a Consulting Engineer of New York city. He has made a special study of the subject of economic transportation from the Lakes to the Seaboard. Mr. Richard Lamb was formerly a United States Assistant Engineer, where he gained direct experience in canal work. He is now Chief Engineer of the Brooklyn Dock and Terminal Co.

We might go into much more detail with reference to the professional standing of the several contributors to our symposium, but it is needless, for engineers generally will agree, we are sure, that a more competent expert jury of twelve men to pass upon the question we have submitted could hardly be selected.

These men have no personal interests at stake. They are not advocates of one side or another. Each has given at our request his own personal opinion, looking at the question from the broad standpoint of the interests of the state as a whole, and each one, it may be added, without knowledge of what opinions others had expressed.

No such weight of expert opinion, unbiased by personal interest, has anywhere and at any time been presented in favor of the barge canal proposition. If in the face of such testimony the voters of New York decide to undertake the barge canal, well and good. The only point we wish to emphasize, and we can hardly express it too strongly—is that the engineering profession must not be held responsible for the success of the barge canal enterprise. If the barge canal is undertaken and it is found in later years that it is unable to compete with Canadian waterways, or with railways, or that the hoped-for benefit to commerce and industry is not obtained, let it not be said that the work was undertaken without warning from the engineering profession.

No further comment of ours could add to the force of the arguments furnished by the letters which we print below.

"The Best Interests of the People of the Entire State Require the Defeat of the Measure."

Sir: Replying to your letter of Sept. 24, requesting my views as to "What action the voters of New York should take with respect to the proposed barge canal?" I beg to say that in my opinion the best interests of the people of the entire state require the defeat of the measure; for the reason that any waterway requiring transfer of cargoes at Buffalo, will effect little or no improvement over present conditions.

The people of New York state should either unite with those of the other states tributary to the Great Lakes waterway system in asking for a national deep waterway from the lakes to the seaboard, or else save their money by leaving their transportation system as it is.

I wish to say that from a careful study of the transportation problem during the past two years, I see no reason to modify the views expressed in the Report of the Board of Engineers on Deep Waterways, June 30, 1900, and in the "Transactions of the American Society of Civil Engineers," Vol. 45, pp. 224-333.

Very truly yours, Geo. Y. Wisner.

Detroit, Mich., Oct. 5, 1903.

"I am of the Opinion that the Canal Should be Constructed."

Sir: I have the honor to acknowledge the receipt of yours of Oct. 2, requesting my opinion as to the value of an improved canal route between Lake Erie and the Hudson River.

I have read the various reports issued from time to time concerning this important matter and I am of the opinion that the canal should be constructed, both in the interests of New York city, the United States interior, and also the many thriving and industrial centers along its route.

Unfortunately I have not now time to take up the question in detail, but as that feature has been thoroughly discussed by Maj. T. W. Symons, of the U. S. Corps of Engineers, and the Hon. Edwin A. Bond, New York State Engineer, I would suggest that their reports receive every consideration.

At the same time I would respectfully express the opinion that a grain route from the West through Lakes Superior and Huron and thence by rail, or ship canal, to Montreal can be constructed and operated under modern conditions to do this class of business on a large scale, at perhaps less expense than by any proposed scheme leading to New York.

I also think that the Great Lakes, Welland Canal, and St. Lawrence River route can be reconstructed to do the work in the same satisfactory and economical manner. I remain, Sir, Yours very truly,

W. T. Jennings, M. I. C. E.

Toronto, Ont., Oct. 17, 1903.

"The 12-Ft. Barge Canal Appears to Me Too Expensive for Local Purposes and Too Small for Interstate Purposes."

Sir: Yours of Sept. 24 is duly at hand regarding the question of a barge canal through New York State, for 1,000-ton barges using 12-ft. depth of canal, at $101,000,000, or thereabouts.

I have not at present the time to go into this subject carefully and thoughtfully. I can only therefore express my general opinion, which is, that it is for the best interests of the United States as a whole that a canal be secured as soon as practicable from the Great Lakes to the ocean, such as will allow the passage of large steamers which shall be able to take cargoes directly from the Great Lake harbors to the Atlantic coast harbors—say from Duluth to Boston, New York, Baltimore, Philadelphia, Norfolk, Charleston, Savannah and Fernandina—without need for transfer of cargo on the way. In my opinion this will be of immense final advantage to the Northwest, Northeast and Southeast of the United States, and all these sections can well afford to be taxed reasonably for the same. A 19-ft. ship canal will do this at a reasonable cost; and should receive all possible encouragement from New York state as well as the other states to be benefited. The 12-ft. barge canal appears to me too expensive for local purposes and too small for interstate purposes.

Very truly yours, W. H. Bixby,

Major, Corps of Engineers, U. S. Army.

Engineer Office, U. S. Army, Jones Bldg., Detroit, Mich., Sept. 26, 1903.

"The Federal Government Should Complete Its Survey and Construct an Adequate Ship Canal."

Sir: I wish to say in regard to the proposition of bonding the state of New York for the purpose of building a barge canal, that I am personally opposed to the proposition and hope that the popular vote will be adverse. I have read your editorials and have also read opinions and heard speeches both in favor of and against the proposition and I have arrived at the conclusion that the Federal Government should complete its surveys and construct an adequate ship canal, by means of which the larger vessels can if they wish transport their cargoes without change while such a deep canal would also accommodate all the smaller traffic, including the proposed 1,000-ton barges, so that their economical advantages could be proven if they exist. I believe the Federal Government owes it to the state of New York, which is said to pay one-sixth of the Federal revenues,to construct the proposed deep-water canal. The state has already paid its share for such a canal, and its construction would not merely benefit some favored locality, it would benefit the entire country, for, as has already been pointed out by others, even the Pacific states would be brought into contact with the central states by direct water connection through this and the Isthmian canal. The affirmative side of the question regarding the vote on the proposition has not been proved to my mind, though the missionary work that is being done in its support is alarmingly significant. I fear that the control of the elevators is in the hands of

those who would like to see a new canal that would be just large enough to ensure the need of transhipment and not large enough to make such transhipment unnecessary. Very truly yours,

Horace Andrews.

Albany, N. Y., Oct. 15, 1903.

"It is Not to the Interests of Our Citizens to Pledge Ourselves to the Smaller Work."

Sir: I understand the situation to be as follows:

First. Long-continued agitation resulted in plans evolved by the state for the so-called "One Thousand Ton Barge Canal." This channel would follow the line of the old Erie Canal, be about twelve feet deep, cost about $100,000,000, accommodate small vessels only and greatly improve present conditions.

Second. The same agitation resulted in independent studies and a later more mature report to the National Government. A new and improved location is proposed, natural waterways are utilized, a depth of twenty-one feet obtained, the time of transit greatly lessened, large lake vessels could pass through to New York city, the cost of $200,000,000 would be partly borne by the United States.

Third. As Item 1 presents improvements over present conditions, so Item 2 suggests improvements over those noted in Item 1. It is obviously to the advantage of the citizens of this state that the larger, more permanent work be obtained. The latter work, although more expensive, will be paid for in large part by the National Government. It is to the advantage of our citizens that Government funds should be received rather than State funds be raised. Also a large canal can obviously accommodate small boats as well as large ones, whereas a small canal is restricted to small boats only. The barge canal must necessarily be considered in the light of a temporary undertaking.

For these reasons I believe that it is not to the interest of our citizens to pledge ourselves to the smaller work.

Yours truly, Chas. H. Snow.

New York University, New York city, Oct. 14, 1903.

"The Barge Canal Proposition Should be Rejected."

Sir: Replying to your inquiry as to my views upon the "Barge Canal" proposition, I would say:

As an abstract proposition, the question of water transportation from the Lakes to the seaboard is one that affects very largely interests beyond the limits of New York state, and its satisfactory solution can only be accomplished with their coöperation, so that the expenditure by this state of so great a sum as $100,000,000 without an assurance that those interests will utilize the waterway to be constructed, seems a questionable procedure at best.

Viewing the matter in the light of present and prospective developments in transcontinental navigation, the investment appears even less attractive. Our Canadian neighbors are at present completing plans for the construction of a ship canal 22 ft. in depth from Georgian Bay to Montreal, of which only about 30 miles will be canal, the rest open river and lake, which renders it possible to deliver a cargo from Duluth or Chicago, at Montreal, ready for ocean shipment, within less than a day's time more than is now required to land a similar cargo at Buffalo. With this canal in operation, the patriotism of the Northwest will not be sufficient to keep the route of traffic to New York with a transshipment at Buffalo, and the proposed barge canal could only receive shipments for distribution along its immediate route. A very considerable portion of its traffic at present distributed from New York as a center, would be diverted to Canadian and New England centers.

In view of this, it is the writer's belief that the barge canal proposition should be rejected, and that the state of New York should unite with the interested states of the Northwest and elsewhere to secure at the earliest possible moment the construction of a ship canal from the Lakes to the most available American port, which, in the light of present conditions, is unquestionably New York city.

Very respectfully yours, Gardner S. Williams.

Cornell University, Ithaca, N. Y., Oct. 17, 1903.

"It Would Pay the People of the State of New York to Build the 1,000-Ton Barge Canal."

Sir: In the following communication I am considering the interests of the state of New York only. I believe it would pay the people of the state of New York to build the 1,000-ton barge canal. There are advocates of a larger canal from the Lakes to the Hudson, to be built presumably by the United States government. But this country has a waterway to build elsewhere which will absorb for a number of years all the money it has to spend for canals. Even if an Isthmian Canal were not to be built, sectional jealousy would probably prevent the expenditure in this state of the great amount necessary to build a ship canal. The practical question is: Shall the state build the canal or go without one?

The Erie Canal did an enormous amount of good in developing the industries of this state. Those who say it did not pay, consider only the direct income derived from it. Indirectly it paid enormously. It paid for its own construction and operation also until its methods of operation became absolutely obsolete. It has not been proved anywhere that a 1,000-ton barge canal operated by modern methods could not in the future be made to pay. There is no proof that it would not pay for its construction and operation as well when the great future developments of the Middle West are considered. But even if it did not pay entirely for its construction and operation directly, it would I believe be a valuable possession for the people of this state. It would bring business to the state. It would help to develop industries which would bring business to the railroads also. While its indirect benefits might not be relatively as enormous as those of the Erie Canal in its earlier days, they would, I believe, still be so great as to make it a good business proposition for the people of the state to build it even if it were always to be a free canal.

But there is another reason why it should be built. Combinations of the trunk lines have already begun. Where are they to end? Much has been made of the so-called ethical side of this question. Has the state the right to compete with an existing railroad within its own borders? Why not ask also has the state the right to grant a franchise to another competing railroad? Has a government any more right to regulate rates by a commission than it has by a canal? Coal road agreements are so complete that last year I had not only to pay a high price for coal, but practically had to buy it from a particular agent. The institution for which I bought it had been parcelled out to him and I could hardly get perfunctory bids from others. This was not a question of ethics nor of fractions of a mill per ton-mile either. It was a question of combination and extortionate charges. Was there much "ethics" in the celebrated "gentlemen's agreement?" It might seem that I show animus against railroads. On the contrary, I hardly ever invest in anything else than railroad bonds or stocks. I think the railroads can take care of themselves. They would still pay if the canal were built. But I believe that the canal could and would be kept as a regulator of rates; that it would tend to prevent discrimination against the people of this state and that it would develop new business for the people of this state. Palmer C. Ricketts.

Troy, N. Y., Oct. 5, 1903.

"I am Sure the Proposed Canal Does not Answer the Requirements of the Times."

Sir: In your letter of Sept. 24, 1903, you ask, "What action should the voters of New York take with respect to the proposed barge canal?" In answer, I may say that this is purely a question of economics and every voter ought to answer it according to the best judgment he is capable of bringing to bear upon it.

As for myself, while I do not pretend to advise the voters of New York, nevertheless I am sure the proposed canal does not answer the requirements of the times. There is now on the upper lakes a fleet capable of carrying from forty to fifty million tons annually, which is awaiting an outlet to the sea, while on the other hand, a barge canal fleet from Buffalo to New York must be created. So far as known to the writer, there are no boats of the type proposed to be used on the barge canal in existence anywhere. Estimates show that it will cost from $18,000,000 to $20,000,000 to construct from 1,000 to 1,200 such boats. A fleet of this number would be sufficient to carry a traffic of 10,000,000 tons per year. Later on, if the traffic increases, another thousand boats, requiring about equal expense, must be constructed. We have, then, ultimately, anywhere from $35,000,000 to $40,000,000 substantially thrown away in the construction of a special form of boat to be used on the barge canal.

The foregoing takes no account of the considerable economic importance of permitting the lake fleet to pass at the beginning of winter from the lakes to the seaboard, engaging in coastwise and other commerce during the winter months. It is a fact that a large proportion of the lake fleet at the present time is amply strong for such service, and as time goes on and new boats are constructed, in view of the comparatively small additional expense of making lake vessels seaworthy, a still larger proportion will become available. So long as the lake fleet is land-locked, there are four months of lost time each year.

But this is only one case where the first principles of economics are violated. At present, docks and elevators are lacking at both Buffalo and New York for the loading and unloading of the special type of boat to be used and, hence, such must be constructed at a cost of several millions more. With the exception of Rochester and Syracuse, there is no provision for harbors, although it is clear that with barges operated by steam, it is unsafe to lay boats up alongside as is the custom now. On the canalized Mohawk River section there is, of course, ample room, but additional width should be provided at Lockport, Middleport, Medina, Albion, Holley, Brockport, Spencerport, Pittsford, Fairport, Macedon, Palmyra, Newark, Lyons, Clyde, Savannah, and Rome. Nor are there any harbors on Oneida Lake, although this lake is over five miles in width, with large stretches of deforested flat country on all sides. Severe storms are frequent, and without proper harbors the loss from wreckage will be considerable. The cost of proper harbors may be easily placed at several millions.

Moreover, there is the cost of concrete [illegible] in embankments to be added before this canal can be in any proper sense a national highway for commerce. There are a number of other refinements to be added at considerable expense in order to place the barge canal in line with the best modern thought.

To sum the matter up. When these several items are included, the cost of a barge canal is about as great as the cost of a deep waterway, and we still have a canal of only about one-ninth the capacity. My objection to the barge canal, therefore, is that an expensive plant must be created, while by making the canal somewhat larger, there is in existence on the Great Lakes a plant which has been developed on the best economic lines of the day. To not avail ourselves of existing facilities would be a huge economic error. Geo. W. Rafter.

Rochester, N Y., Oct. 3, 1903.

"The Building of a Narrow and Shallow Barge Canal Would be a Colossal Financial Blunder for the State of New York."

Sir: I am in receipt of your letter of Oct. 2 in which you ask me to answer the following question, and also to state my reasons for my opinion. It gives me pleasure to comply.

"What action should the voters of New York take with respect to the proposed barge canal?"

My answer is, that in the best interests of the state of New York, they should vote *against* the measure. And in so saying I do not dissociate the interest of the metropolis or of any section of the state or of its commerce, from the general interests of the whole state. I am not, however, opposed to the idea of providing better water communication from lake to ocean within its borders; on the contrary, I strongly advocate the construction of an adequate waterway which shall be ample for the demands of the future development of the state and of the nation.

The measure of capacity of such a channel should be, in my judgment, not a small barge of 1,000 tons as is now proposed, but the largest vessel which could navigate the lakes.

My reasons for this opinion are briefly these:

(a) A deep waterway would afford much better accommodation for barges and other small craft than the proposed barge canal, in point of larger capacity, superior speed and greater freedom from interruption, so that whatever valid arguments exist for the barge canal apply with added force to the ship canal.

(b) New needs of state and nation, some of which are apparent already, and others which require no prophet to foretell, would be met by a ship canal, but can in nowise be provided for in the barge canal, because of its puny dimensions. It would be an act of inconsiderate folly, in my judgment, to disregard those needs; and the building of a narrow and shallow barge canal which could not provide for them would not only be a colossal financial blunder for the state of New York, but would lay an embargo on the future natural commercial development of the country and incidentally of the city and port of New York, the very interests in fact which the barge canal is vainly, in my judgment at least, expected to conserve, but for which it would be utterly inadequate and ineffective.

Time and space do not permit of enlarging on these objections.

I was present, as an interested auditor only, at the hearing at Albany last winter before the joint committee of the legislature, when the bill was pending, and I heard the able arguments advanced both for and against the measure by many persons, among whom were several prominent engineers, who had reported in favor of a barge canal and were there to defend their estimates and advocate its construction. So far as I can recall, no statements were then made concerning the feasibility of building and operating a barge canal which would fail to apply also to the project for a deep waterway, excepting in point of cost and choice of route. In the event of the rejection of the barge canal and adoption of the latter plan, it is conceivable that the citizens of the state of New York might reasonably be expected to contribute directly a share of the greater cost and might find it to their interest to do so, but it is not to be supposed that their proper share would approach the sum which they are now asked to vote away without any tangible evidence of its ever being returned.

(c) The voters before being asked to vote upon the small and ineffective barge canal should have distinctly placed before them the relative merits of the deep waterway. This has not been done, notwithstanding that the very able report of the U. S. Deep Waterway Commission would have been available for the purpose. Where there is so much to be considered, as in this case, it is not fair to the voters to place before them a single proposition which the spirit of progress may lead them to accept in their ignorance of the more beyond.

(d) In my humble judgment the barge canal by itself could not exert much influence on the question of economic transportation from the Lakes to the seaboard. Despite all that has been said and written on the sub-

ject, there is no evidence that the Erie Canal ever really acted to lower transportation rates. Viewed dispassionately and in cold arithmetical light, the figures of the evolution of railroad transportation through New York state serve to prove conclusively that while the efforts to cheapen the cost of rail-carriage may at one time have been stimulated and perhaps even suggested by the then greater cheapness of canal carriage, yet the lowering process went far beyond the suggestion and soon it was the other way about and the state had to come to the aid of the canal, abolish tolls and spend large sums in enlargement and maintenance to enable the boats to meet the rail-rates and only thus was the figment kept up. It is long since the point of equation was passed and while the canal rate could drop no lower, the rail cost, affected by entirely different elements of competition, has continued to grow less and less and still has some reefs to let out. There is little to indicate and certainly nothing has been advanced which proves that the barge canal with its slightly greater depth and width of boats, can effect what the Erie Canal has failed to do and the presumption is all against such a conclusion.

With a deep waterway the case would be different, for not only would the cargo capacity be sufficiently great to realize the advantage that accompanies water transportation of goods in bulk, but the higher speed and freer communication would greatly extend the list of commodities to be shipped by water.

I need not dwell on the need of the country for untrammelled water communication from our inland seas—which they will be, and no longer lakes, when thus they are joined to the ocean, by means of a waterway with no limitation of depth excepting that which nature herself has established for the lakes.

Very truly yours, Foster Crowell, C.E.

18 Broadway, New York, Oct. 5, 1903.

"The Promised Advantages to the Public from the Construction of a Barge Canal are Dreams that Will Not be Realized."

Sir: What action should the voters of New York take with respect to the proposed barge canal?

I respectfully submit the following answer to the above question, on which you request my opinion:

Numerous isolated canals that were once useful means of transportation have been abandoned as useless, while systems of canal and canalized river transportation are being greatly enlarged in Europe, and are successful in competition with railroads. A comparison of these successful canal systems of Europe with the unsuccessful isolated canals of America shows that the essential difference between them is that the former connect large regions of production and consumption by a navigation without transfers, while the latter transport only a little freight from its origin to its destination without transfer, either before it reaches or after it leaves them.

This is the cause of the success of canal systems and of the failure of isolated canals.

The cost of mere transport between terminals was formerly much less on canals of large traffic than on railways. This cost has been greatly reduced on both, and with it the amount of the difference, and the importance of this item in the total cost of transportation.

Terminal costs and delays are now the most important element in both canal and railway transportation.

The proposed barge canal does nothing to reduce or remove these terminal costs and delays, or even to prevent their increase by monopolization. It will be an isolated canal, requiring transfers for all freight either coming from or going to points beyond. On account of these transfers no quick, reliable, and cheap service would be possible for through freight, and no very large amount of such freight can therefore be expected by a barge canal.

The most enthusiastic defenders of a barge canal have been unable to show that the yearly saving in cost of transportation to be achieved by it can come anywhere near the yearly cost incurred by the New York taxpayer for covering interest, amortization, and maintenance charges. They therefore rely on indefinite assertions about the savings to be secured by the public on account of lower freight rates on the competing railroads.

It can be easily shown that these promised advantages to be secured by the public from the construction of a barge canal are dreams that will not be realized.

Through transportation on such a canal is dependent on transfer facilities at both ends. Such transfer facilities must be accessible to both canal barges and lake or ocean vessels. The space available for such purpose is limited. Experience in the past has shown that it is entirely practicable to monopolize these transfer facilities. Exorbitant charges for transfers have long been prevalent in New York and Buffalo. The public is helpless against them, and has looked on passively, though they were one of the main factors in destroying the usefulness of the present canal. If a barge canal is built, either the existing transfer associations, or large companies able to provide their own transfer facilities, will build fleets of barges and can arrange their transfer charges to outsiders in such a manner that the main profit of all through traffic is in the transfer business. Those controlling the through traffic would furnish the best service for local traffic, and could thereby indirectly control this also. Owners of barges only will therefore be in a precarious position, analogous to that of the independent anthracite mine owners. They will own a part of the plant necessary to render a service to the public, while another essential part is owned by the transfer companies, who will, as past experience has shown, combine to maintain excessive rates. The railroads, which already control the New York transfers, will have the strongest possible motive to keep the transfer charges high so as to protect the then existing railroad rates, even to the extent of sacrificing profit from the transfer business on account of the small amount of canal traffic which must be the effect of the excessive charges. The experience with the Canadian canals has shown that the construction of a special fleet, fit for a canal of limited depth, is a slow process. It may therefore be expected that the growth of business on a barge canal will be a slow one, and the railroad companies will see to it that the freight charges will not be a danger to the maintenance of their freight rates.

Only where the conditions for competition are very favorable are the prices equal to the cost plus a moderate profit. It is evident that this will not be the case with transportation on a barge canal corked up at both ends by transfer companies. It is therefore to be expected that the benefit which would be derived from a barge canal, even if the saving in cost of transportation between Buffalo and New York were as large as asserted by its advocates, would largely go to the interests controlling the transfer facilities and not to the public. The amount of through business on such a canal would therefore be small on account of the inferior quality of service, due to transfers, and high freight rates.

The transfer interests that have pushed the barge canal bill through the Legislature are sellers; the producers and consumers, served by a canal, are buyers of transportation services. Their interests are directly opposed. The former wish to maintain as high prices for canal transportation as railroad competition allows. They therefore insist upon a barge canal which makes active competition among those furnishing the complete transportation service impossible. The latter wish to secure low prices for canal transportation. For obtaining these it is absolutely essential to secure active competition among all who are necessary to furnish the complete transportation service. This can only be obtained by a ship canal or by the public ownership of the transfer facilities.

Either of these would defeat the schemes of the canal promoters and would make them opponents instead of advocates of the canal. A 12-ft. deep barge canal would undoubtedly considerably decrease the cost of mere carriage by water between Buffalo and New York if the cost of construction and the consequent interest and amortization charges, and the cost of maintenance of the canal are neglected in the calculation. Here again the interests of the sellers of transportation and those of the public are directly opposed. The cost of carriage is paid by the seller of transportation, the last mentioned elements of cost by the public. The general public has but a remote interest in the cost of carriage unless this brings about a reduction in the price of transportation, which would only be the case with free competition. Cost of construction and maintenance are of little consequence to the canal promoters since they will be saddled upon the public.

The whole proposed barge canal is a reckless scheme for robbing the public of New York state for the benefit of a few present and prospective owners of transfer facilities in Buffalo and New York.

It is condemned by the most competent engineers who have given the subject serious study. If approved by the popular vote it will saddle the state with an enormous yearly burden in the form of taxes and will inevitably much delay a most meritorious enterprise, that of building a ship canal between the Lakes and New York, which would be of enormous benefit to the state and the Union! Such a canal would secure free competition among carriers and the public would be its beneficiary through an enormous reduction in the cost and price of transportation betwen the West and the East, even if all the charges due to cost of construction and maintenance were paid by the carrier, in the form of tolls, and by him charged to the public. Joseph Mayer.

No. 1 Broadway, New York, Oct. 17, 1903.

"The Voters of the State Will Make a Grave Mistake in Authorizing the Improvement."

Sir: In reply to your communication of Oct. 2, asking, "What action should the voters of New York take with respect to the proposed 1,000-ton barge canal?" it is my opinion that they should defeat the project.

I regret that I have not time to make an exhaustive study of the official reports of the United States Commissions and of the State Engineer, and especially of the Superintendent of Public Works of the state and of the transactions of engineering societies, and to show, as I feel confident that it can be shown, from statistics of the canal and from the information gathered and accumulated by the engineering profession, that the Erie Canal, in its present location, has fulfilled its mission and is no longer required as a commercial highway except for the villages and cities along its line, which are fully served by the canal in its present condition.

A tabulation of the gross tonnage of the Erie Canal, since the year 1880, with the exception of 1890, shows that the tonnage carried has steadily decreased and that in 1898 it was little more than one-half what it was in 1880. This is true in the face of the fact that the official tonnage of the canal has been exaggerated and swelled to make a good showing, as is well known to those officially connected with the canals. Every move of a canal boat is reported at its maximum tonnage with little, if any, regard to the distance. A report of the actual ton-miles, if it could be had, would, I am satisfied, show a much greater depreciation in the actual tonnage of the canals. The average gross tonnage, as reported for the years 1880 to 1898, was four and one-third million tons.

A statement of the tonnage up and down the Hudson River between New York and Cohoes and which passes through the Erie Canal and a description of the class of freight carried would, I am sure, be interesting campaign literature, and I would suggest that the advocates of the 1,000-ton barge canal make a tabulation of the tonnage for the past ten years and present it to the voters of the state, especially in those counties remote from the waterway. I would have it extended also to the tonnage passing through the Champlain Canal and the Oswego Canal.

In 1896, while engaged upon the improvement of the Oswego Canal, I had every opportunity of observing the traffic through that waterway. The traffic was limited to one boat load of clay from Belgium to Syracuse, about twelve miles, every other day, and perhaps once a week a boat load of molding sand from Lake Ontario. These, with two or three stray loads of lumber per week going either way, was the total tonnage of the canal. For such an amount of traffic, when compared to the amounts of money proposed to be expended upon the Oswego Canal, under the extreme engineering difficulties encountered, it would be folly to undertake such an improvement.

I venture to declare that the proposition of building and operating a 1,000-ton barge canal from Buffalo to Cohoes, Syracuse to Oswego and Cohoes to Lake Champlain, if presented to Wall Street or to investors expecting a moderate return income on their investment, could not secure the loan of $10,000,000, whereas the state proposes to invest $101,000,000 under promise to the farmers and manufacturers, even in the districts remote from the canal, that their feed products and the raw products which they are required to purchase will be enough cheaper to compensate them for the extra taxation required to meet the cost of the colossal project. Statistics belie this statement and the real and only persons who will profit by this improvement will be those villages and cities along the line of the canal, where the money will be spent and where manufacturing may be stimulated.

That the motive of at least a part of the present administration of affairs at Albany is to secure a fund with which to sop the canal cities and counties is shown by the following table prepared in the office of the State Engineer, who will have the disbursing of this enormous fund:

County.	Share of cost.	Amount to be expended in county.	Net gain.
Monroe	$2,372,370	$14,470,000	$12,097,630
Oneida	983,740	11,920,000	10,936,260
Schenectady	363,600	3,830,000	3,466,400
Montgomery	435,100	8,840,000	8,404,900
Herkimer	360,570	7,280,000	6,919,430
Oswego	461,570	6,400,000	5,938,430
Onondaga	1,821,030	6,170,000	4,348,970
Cayuga	567,620	890,000	322,380
Wayne	444,400	9,556,391	9,111,991
Orleans	261,590	5,910,000	6,648,410
Niagara	690,840	5,870,000	5,179,160
Rensselaer	1,791,790	2,730,000	938,210
Saratoga	444,400	9,070,000	8,625,600
Warren	131,300	380,000	248,700
Washington	313,100	6,990,000	6,676,900
Total	$11,443,020	$100,306,401	$88,863,371

The table shows that on an average for every dollar paid in taxes by the chain of canal counties, exclusive of Erie and Albany, ten dollars will be spent in those counties to carry out the work, from which it follows that for every dollar of tax that the canal counties pay the other counties of the state remote from the canal will pay nine dollars; and if the work is conducted as was the $9,000,000 improvement, the outlying counties may congratulate themselves if they get even a few laborers employed upon the improvement.

The total ton-miles of traffic carried by the canal, when compared with that of the railroads paralleling it, is a mere bagatelle of that carried by both, yet the cost of the proposed canal improvement per mile, it is safe to say, is several times greater than the cost of constructing the two steam railways paralleling it, excluding equipment.

With the experience of the state and the public with the other improvements and the underestimates made by former state engineers and surveyors, voters will go to the polls with little assurance that the said $101,000,000 will effect the improvement proposed, and well may they be in doubt when they consider the difficulties that must be surmounted to make this enlargement. Locks and viaducts must be enlarged, the canal widened and deepened, and there are long stretches between Utica and Syracuse, and Syracuse and Rochester, where the bottom of the canal must be puddled and the banks must be reinforced; and even after the canal is constructed it is very doubtful if the water supply is sufficient to operate the canal or if it can be

made sufficient. There has been for many years with the present canal a want of water with which to operate it, and notwithstanding the scandalous use of water by mill owners it is extremely doubtful if, with that curtailed, there be water enough in the whole Adirondack region to supply a 1,000-ton barge canal; the opinion of others to the contrary, notwithstanding. The improvement of this water supply to meet the requirements of the 1,000-ton barge will require a great sum of money.

My study of the canal question and my experience in the construction of the Erie Canal and in the survey and investigation of the water supply, have led me to honestly believe that the present proposed improvement of the Erie Canal and its tributaries is ill-advised and that the voters of the state will make a grave mistake in authorizing the improvement.

To defeat the project will require something more on the part of those counties and cities remote from the canal than a refusal to vote for the project, for the united voting strength of those cities that will be directly benefited will practically determine the question. To defeat it, will require strenuous efforts on the part of those communities who will contribute their share of the tax, and who will derive little or no benefit from the improvement.

Respectfully yours, John C. Wait.

New York City, Oct. 19, 1903.

"The Results Sought from the Barge Canal can be More Economically Obtained."

Sir: I have your favor requesting my views as to "What action should the voters of New York take with respect to the proposed 1,000-ton barge canal?" I would reply, they should oppose it.

(1) Because the results sought, namely, providing a waterway for the transportation of ten million tons of freight per year can be more economically obtained, and at a low rate of cost for transportation.

(2) Because it destroys vested rights in present canal boat property, and does not provide for any assured replacement of the boats by 1,000-ton barges.

(3) Because it opens up a gigantic field for legal complications and political corruption.

The object of the improvement of the Erie Canal is to compete with railroads to keep down the freight rate from the West to New York. New York state possesses the only practical route for a canal from the Western states to the Atlantic coast, except via Canadian waters; and water transportation can be made more economical than by rail.

The Roosevelt State Canal Commission considered four projects, as follows: (1) Completing the nine million dollar canal improvement; (2) extending the same to allow boats 115 ft. long to pass the locks; (3) a canal to admit boats 125 ft. long, 17½ ft. wide and 8 ft. draft; (4) the project, which they recommended, for barges 150 ft. long 25 ft. wide and 10 ft. draft. The estimated costs of these projects, respectively, were: $12,923,639, $15,068,048, $21,161,645 and $58,894,668. They were each estimated to accommodate a traffic of ten million tons per year.

State Engineer Bond's estimate for a canal of ten million tons per year capacity was $72,264,826. These estimates do not include improvement of the Oswego and Champlain Canals.

The Bostwick bill originally called for an appropriation of $81,000,000, which included $6,231,620 for the Oswego and Champlain Canals. While under discussion in joint legislative committee, errors were discovered in estimates due to changes in prices of materials and labor, and the amount asked for was raised to $101,000,000.

All of these estimates are for the same capacity canal; the only justification for any additional expense over the minimum estimate lies in the cost per ton for carrying the freight. The Roosevelt Committee reported that during 1899 the average freight rate per ton-mile for the Erie R. R. was 0.52 cts., for the New York Central & Hudson River R. R., 0.59 cts., and for the New York canals, 0.19 cts.

The estimate of the cost of running boats per ton-mile when using the $21,161,645 canal is 0.88 of a mill, and if using the $101,000,000 bill canal, 0.52 of a mill. Every one will admit that canal rates from Buffalo to New York are and can always be less than rates via railroads. There has been no claim that the 1,000-ton barges were to be built for lake navigation. The propelling boats at least would be unsuitable. During 1881 there were 65,000 tons of vessels constructed on the lakes, three-fourths of which were steam vessels averaging 450 tons. It is best to have powerful sea-going tugs to tow the barges in the lakes, and a tow of four 450-ton barges is perfectly practical. Iron barges of 235 tons capacity towed by a canal barge of 130 net tons capacity successfully navigated the lakes and Erie Canal, but they were found unprofitable.

In freighting coal from Virginia to New England points, powerful sea-going tugs have no difficulty in towing three or four barges. But to design a boat suitable to navigate a canal without too great swash of water from the propeller, and economical in coal consumption when going slowly, and which is also capable of towing heavy barges at sea, is a difficult and as yet unsolved problem. All vessels passing in and out of Hatteras inlet for New England and other Atlantic ports draw 8 ft. of water or less. Then have your barges of 8 ft. draft and made suitable for lake or canal navigation. The Dortmund-Ems Canal in Germany has boats carrying 1,041 tons that draw only 6.6 ft. of water. The canal is 8.5 ft. deep. These boats require less power to propel them than the proposed 1,000-ton barges for the Erie Canal.

The traffic of the Erie Canal to-day is chiefly to and from interior points on the canal. During 1862, 5,698,785 tons of freight was transported on the Erie. During 1902, 2,105,876 tons were carried. Of this 509,568 tons started from Buffalo and 318,700 went to Buffalo. There are more boats on the canal now than there were in 1862.

We must look to the lake ports for the additional freight to make up the 10,000,000 tons. Bulk should not be broken at Buffalo as heretofore, but boats should be turned over to the Erie Canal by large Lake tug boats, and the most economical method should be adopted to tow the boats through the canal. After passing through, powerful tugs can tow the barges to New York. The state should advertise for tests of all methods of towing and the most efficient should be adopted.

New York state not alone possesses the only practical route for a canal from the West to the Atlantic, but along that route is to be found the greatest water power on earth. With this power converted into electricity, unquestionably the boats can be towed for less money than would be the case on any other lengthy canal in the world. With a practical and profitable electric transmission line of 220 miles in length—the Bay Counties plant in California as a precedent—and with available water powers at several places along the line, the question of cheap electric current is assured. It would therefore be best for the state to build a 9 ft. deep canal for 450-ton barges and provide electric towage and electric power for operation of locks, bridges, lights, etc.

In estimating the difference in cost for handling 10,000,000 tons of freight per year via the 450-ton barge canal and the 1,000-ton barge canal, the additional profit to the canal boats should not be the chief consideration. The cost to the taxpayers of the state for building and maintaining this safeguard of its commercial supremacy should be paramount. The maintenance of the Erie Canal since 1883 has averaged $427,824 per year, and even with this great sum expended, it is a fact that since 1862 the prism of the canal has not been maintained by dredging except from time to time, at places where it had become unnavigable, and except in such parts of the canal as were improved by the $9,000,000 appropriation. With 1,000-ton barges navigating a canal such negligence would not be practicable.

The cost of maintenance of the Erie Canal has averaged 14 cts. per ton of freight carried. This would be greatly increased in the larger canal. The interest on the cost and the annual sinking fund will be far greater. The propellers and swash of the larger boats will wash away the banks more extensively, causing greater maintenance cost. It will require more water, as the seepage and percolation are proportional to the square root of the head of water, and directly as the wetted surface. A larger amount of water will also be lost from evaporation and absorption by plants; leakage at aqueducts, culverts and waste gates; leakage of lock gates and valves; loss over waste weirs; water for power to operate locks; water for power for additional electric lights at locks; water for lockages. These losses have been investigated by the engineers and are calculated as being very considerable. In the case of only 5,000,000 tons or less being carried, the above-named losses remain constant. A larger cross-section of canal, even with a moderate current of water, implies a much larger volume of lost water at points of overflow. If the old Erie Canal had not had such difficulty in regard to maintaining sufficient water, we might feel that all provisions for this additional water needed for the larger canal could be easily met. No provision in the estimate has been made for the extraordinary demands, such as giving way of embankments on long levels and dams. This year there has been considerable loss of water from this cause.

The state gets no revenue from the canal, and will not by the 1,000-ton barge bill now before the people. If part of the cost of this unnecessarily large canal were used in building an electrical plant, the state could derive a revenue from towing the boats, and save costs in handling the mechanism and lights of the canal.

Mr. Elnathan Sweet, the expert on tractive resistance on the 1,000-ton barge canal, rightly concludes that in the new canal a speed of 3 miles per hour is the maximum economically admissible, and he stated that it requires 53 HP. to propel a 1,000-ton barge at the rate of 3 miles per hour. This can be done by electric haulage with 29¾ HP. This means that the motive power alone will cost per season for steam propeller $3,180 for one 1,000-ton barge, as against $595 for one 1,000-ton barge towed electrically.

If the proposed 1,000-ton barge canal bill is made a law, you might as well have subsidized some railroad to carry during the canal months 10,000,000 tons of sixth-rate freight at the lowest prevailing rail rate, less amount the annual charges would have been on the large canal. This would maintain our commercial supremacy at the state's sole cost and expense.

You can, however, make the present canal a real competitor of the railroads, so that through bills of lading from the West can be issued for New York deliveries without rehandling charges, and freight carried at a far lower rate than the railroads can carry it, by economically improving the present canal and its fixtures, and by taking advantage of the vast water power near by to generate electricity, and to furnish a revenue to aid in the cost of maintaining the canal, as well as in lessening the cost of transporting freight through it.

Yours respectfully,

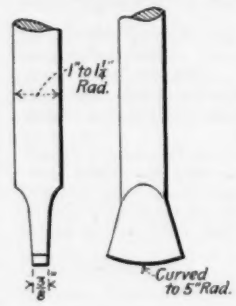
Richard Lamb, C. E.

136 Liberty St., New York City, Oct. 19, 1903.

LETTERS TO THE EDITOR.

A Bit for Drilling in Earth with Steam Drills.

Sir: The last issues of your paper have contained articles on drilling in earth or shale rock, and I have been surprised that the steam or air drill seems to have been set aside entirely for this sort of work. If this is the general practice it would seem very unfortunate, especially in view of the fact that underlying nearly all shale rock is a harder stratum which requires the use of the air or steam drill.



Recently I had charge of some excavation starting in hard clay, which gradually changed to a shale sandstone, and this to a hard blue sandstone. I very quickly discovered that the X-bit of the air drill would not work, and I substituted a bit as per sketch. This blunt straight bit worked nicely. I have no exact data, but would say that this bit worked as much better in dirt than the ordinary hand drill as the X-bit in rock is better than the jumper or hammer drill.

Trusting this may be of service to some of your readers, I am, Very respectfully yours,

C. M. Ayres, C. E.

Tuscaloosa, Ala., Sept. 28, 1903.

Pile Driving Formulas.

Sir: Several years ago I copied a rule from your paper on the driving of piles; my record is

$$L = \frac{2\,w\,h}{s+1},$$

in which

L = safe load;
w = weight of hammer;
h = fall in feet;
s = last penetration in ins.

In your issue of Oct. 8 you publish a rule which was

$$L = \frac{2\,w\,h}{s+.1},$$

the penetration being plus one-tenth; this latter rule you give for a steam pile driver.

What I wish to find out, is whether I made a mistake in taking off the rule, or whether it was for a different kind of driver?

What would you consider a safe rule for driving with a hand driver (windlass) 800-lb. hammer?

Yours very truly, F. D. Low.

Mansion House, Keyport, N. J., Oct 16, 1903.

[Our correspondent made no mistake in copying the first formula, as above given, for that formula applies to piles driven with a free fall hammer raised by a rope; while the formula given in our issue of Oct. 8 applies to piles driven with the Nasmyth or other steam hammer. For an 800-lb. hand driver probably no formula is more reliable than

$$L = \frac{2\,w\,h}{s+1},$$

—Ed.]

As to the Practice of Measuring Cement Loose or Packed.

Sir: Having had occasion to measure some sacks of Atlas cement, I found that two sacks, turned out into a box of 2 cu. ft. capacity, would a little more than fill the box; but when the box was shaken several times the cement settled 1 in. below the top. The question then arose as to whether cement should be measured loose or packed. Articles written upon the subject of cement and concrete usually state that one sack of Portland cement equals 0.9 cu. ft. in volume. Will you kindly give me the usual practice in regard to measuring cement?

Very truly, Bruce C. Yates,
Asst. Engr. Homestake Mining Co.

Lead, S. Dak., Oct. 16, 1903.

(Practice as to measuring cement for mortar varies; so that to avoid controversy the specifica-

tions should state explicitly whether the cement is to be measured loose or packed. Where a sack of Portland cement is equivalent to ¼-bbl., it holds approximately 0.9 cu. ft. of packed cement, but the exact amount varies with the brand. Some recent specifications make the packed barrel of 3½ cu. ft. the unit of measure, but where the specifications fail to define the unit, the contractor should probably be given the benefit of the doubt and be permitted to measure the cement loose. Laboratory measurements are usually made by weight and not by volume; but a cubic foot of loose quartz sand (45% voids) weighs about 90 lbs., while a cubic foot of loose Portland cement ordinarily weighs about 95 lbs., so that measurement by weight is practically equivalent to measurement by volume of the loose materials.—Ed.)

Notes and Queries.

D. B. M.—I wish to make my Carnegie and other structural steel hand-books more convenient for rapid reference by cutting out the margins of the pages with a half-round chisel, as in a "Webster's Dictionary," for convenience in rapidly turning to any given table in the hand-book. I should like to have your readers suggest what tables should preferably be indexed, for it is obvious that the small size of the page limits the number of thumb holes.

We should doubt the advisability in so small a book of cutting the margins for rapid indexing. Pasting tabs of heavy paper or white kid on the margin of leaves would be a better plan.

SOME OBSERVATIONS ON STREET PAVEMENTS.*

By S. Whinery, M. Am. Soc. C. E.†

So much has been written upon the subject of street pavements in the last ten years that any attempt at present to treat the subject systematically must necessarily involve a repetition of a great deal that has already been written, and generally well written. There is room, however, for the discussion of certain branches of the subject in the light of recent experience and study, and the writer proposes to offer some views upon a few topics which seem to be worthy of further consideration.

I.

Statistics of Street Paving.

In Bulletin No. 30, entitled "Statistics of Cities," issued by the Department of Labor in September, 1900, is published a detailed statistical exhibit of paved streets in all cities of the United States having a population of 30,000 and over. The area of pavement of the several principal kinds, in each city, is given separately. No statistics of the cost of these pavements are given, but we know approximately the average price per square yard of each variety, and using these approximate prices, it appears that the quantity and the cost of the several kinds of pavement in the 129 cities embraced in the report of the Labor Commissioner were, at that time, about as follows:‡

Sq. yds.				
21,880,246	cobble stone pavement....	at	$0.80	$17,344,196
32,716,513	granite block pavement....	"	3.50	114,507,802
21,738,210	brick pavement	"	2.25	48,910,972
27,733,572	wood block pavement.....	"	1.25	34,667,965
34,471,804	asphalt sheet and block pavement	"	2.75	94,797,461
83,841,445	macadam	"	.75	62,881,083
58,601,397	gravel	"	.70	41,023,077
18,432,210	all other kinds pavement..	"	1.00	18,432,210
	Total cost			$432,564,766

The population of these 129 cities was, in round numbers, according to the census of 1900, nineteen millions of people, so that it appears that the investment in street pavements is over $22 per capita of the population. These statistics make no separate account of the large sums that are spent in these cities annually for the renewal of pavements.

Bulletin No. 36 of the Labor Department, issued September, 1901, gives the sums of money expended upon streets during the previous year. These expenditures are classified under the two heads of "Expenditures for Construction and Capital Account" and "Expenditures for Maintenance and Operation," as follows:

Construction and capital account.....	$26,654,588
Maintenance and operation:	
Cleaning and sprinkling.....	10,871,256
Other street expenditures	11,248,184
Total	$48,774,028

We have no means of ascertaining the details of these expenditures, nor what part of them is strictly chargeable to the Construction and Maintenance of Street Pavements, but these items probably absorbed at least one-half of the total, and if so, the expenditure on those accounts must have been, for the year, not less than $2.50 per capita.

These figures are given to show the very great importance of street pavements as objects of public expenditure. From the same Bulletin (No. 36) we learn that the total expenditures of these cities for what may be called municipal public works, was as follows:

For construction and capital account	$82,048,900
For maintenance and operation.....	180,533,900
Total	$262,582,800

From which it appears that about 18½% of the total expenditure was devoted to the streets and probably not less than 10% was devoted to the construction and maintenance of street pavements.

Considering their importance from a financial standpoint alone, it is obvious that street pavements merit the most careful and thoughtful study of the municipal engineer. And yet it must be acknowledged that the engineering and economic sides of the subject have not received anything like their proper share of scientific study and development, however much it may have been discussed in a popular and general way. The scientific, professional and economic aspects of bridge building, of water supply, and of sewerage, have been carefully studied and developed, but for such a study of street pavements not even the necessary data have been ascertained. We have, for instance, no reliable information upon the relative endurance of the several varieties of pavement, referred to some intelligible standard, nor have we any accurate and trustworthy determinations, upon a satisfactory scale, of the coefficient of tractive resistance of the several kinds of pavement. Many of the data necessary to determine the relative economic value of pavements are wanting, and we are therefore quite unable to compute and predict which of the several kinds will, under a given set of conditions, yield the best return per dollar invested in them. Such a condition of affairs is not creditable to the engineering profession, and is not in accordance with the spirit of the age. It is doubtless due in part to the fact that the determination of the necessary constants is a matter of practical tests rather than of mathematical computation, and that the making of these tests would involve the co-operation of a number of municipalities, and would entail considerable expense, which the average city official is not willing to provide for, and which the engineer is not usually able to bear himself. But when all this is admitted it must be acknowledged that the profession has not done what might reasonably be expected of it in a matter of so much importance.

There exists, for instance, no commonly accepted standard by which the endurance of a pavement may be expressed. We still have reputable engineers stating that a particular pavement remains in good condition after a stated number of years of use, regardless of the fact, which every one should now know, that the endurance of a pavement, excluding natural decay, is a function of the quantity of travel over it, and that time is not necessarily a factor in the problem of endurance. And yet it is the common practice in most of our cities to require of contractors a uniform time-guarantee for pavements, regardless of whether the travel is heavy or light.

It is one of the objects of this series of short articles to call attention to the great need of a more scientific study of the question of street pavements, and to briefly suggest the lines along which such a study may be profitably conducted, as well as to note some practical observations relating to pavement construction.

II.

The Endurance or Life of Pavements.

The endurance or life of a street pavement is measured by the aggregate resistance it offers to the elements of natural decay, and to the wear of travel, and the other conditions of use to which it is subjected, before it is worn out. In a pavement not subject to natural decay, it is simply the quantity of work or service it is capable of yielding before it is worn out. The measure of endurance of such a pavement is independent of the element of time. Of course, we cannot say absolutely that any pavement is not subject to natural decay; but the processes of destruction by decay may be, and usually are so slow, as compared with the destruction by use, that the former may be practically disregarded. In other words, if the conditions of use are such that the pavement will be worn out before the effects of natural decay become apparent, we may safely neglect that element altogether. If the reverse be true we must assign natural decay its proper weight in estimating the life of the pavement. We are fairly familiar with the natural life of most of the materials that enter into pavement construction, though our data are not as complete as they should be, particularly as the natural life of these materials is very considerably affected by the conditions of exposure and use. What should be borne in mind is that the two causes of destruction are entirely distinct from each other, though both may operate together to determine the actual life of the pavement.

The destruction of a pavement by the wear and tear of use is mainly caused by the abrasion and the percussion of the wheels of vehicles and the feet of horses, and if we knew the value of each of these, referred to some common unit, and if we knew also the coefficient of resistance of the materials of which the pavement is made, it would obviously be a simple matter to compute what quantity of travel would result in the practical destruction of the pavement. Unfortunately none of these elements are capable of exact and conclusive determination. They are not amenable to the precise methods of the testing machine or of the chemical laboratory. Their average value must be determined by observation and experiment, and units must be derived, which, while they may not be scientifically accurate, will best serve the practical purpose.

Since abrasion is caused by friction, and friction is proportional to pressure, we may safely assume that the wear upon a pavement caused by vehicles varies directly as the weight of the vehicles passing over it. This will be true also of the abrasion caused by the feet of horses, and it is presumably true that the percussive effect of both the wheels of vehicles and the feet of horses varies directly with the weights of the vehicles and the horses. We may therefore assume that the destructive effect of travel upon a pavement is directly proportional to the aggregate weight of the vehicles and horses passing over it. In other words, that the endurance of the pavement is measured by the total weight of the travel to which it is exposed. This conclusion is doubtless true, with certain modifications to be mentioned hereafter. It assumes, however, that the pressure to which the pavement is subjected is not sufficient to crush the materials of which it is constructed.

It is desirable that some convenient and acceptable unit be adopted for expressing the quantity of travel upon streets. Assuming, as we have, that the endurance of a pavement is measured by the total weight of travel over it, the unit desired will be one of weight. The ton is the most common unit of weight as applied to transportation, but it is inconveniently small for application to the aggregate weight of travel carried by a street during its life. A unit of 1,000 tons would be more satisfactory. If adopted it would be desirable to designate this unit by some acceptable short word. The word kiloton is suggested for the purpose. While the combination of metric and English nomenclature may be undesirable, it may be excused when we remember that the English ton is quite comparable, and quite easily converted

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†95 Liberty St., New York City. A brief biographical note on Mr. Whinery will be found under "Personals," elsewhere in this issue.

‡Only the quantities in each individual city are given in the Bulletin. The totals are from additions by myself.

into the metric tonne of 2,204.6 lbs. avoirdupois, which is approximately the same as our long ton. The English long ton is preferable since it differs from the metric tonne only about 1½%. If the metric system should ever become the exclusive standard in this country, the kilotonne might be substituted for our proposed kiloton, without serious error in practical results, and if the kilotonne should in the meantime be adopted as the unit of street travel in metric countries, the domestic and the foreign unit might be considered as practical equivalents. The unit here proposed seems therefore a very satisfactory one. It may be defined thus: The kiloton is the unit of quantity of travel over streets and roads and is equivalent to 1,000 long tons of travel passing over the street. Thus, if a travel-census disclosed that the average daily travel over a street amounted to 60 long tons, the quantity expressed in kilotons per year would be:

$$\frac{60 \times 365}{1{,}000} = 21.9,$$

and if the pavement were worn out at the end of ten years its total endurance would be 219 kilotons.

The necessity of having some such generally accepted unit to denote the work of which a pavement is capable will be recognized by every engineer who has given special attention to the matter. Without some such generally accepted unit, intelligent comparison of the relative endurance of pavements is difficult, if not impossible. Having such a unit we may then say of a given pavement which has been worn out at the end of ten years, the travel over which has averaged 50 long tons per day, that its total endurance has been,

$$\frac{50 \times 365 \times 10}{1{,}000} = 182.5 \text{ kilotons},$$

and of another, of the same width between curbs, that is worn out after carrying 100 tons per day for five years that its total endurance has been

$$\frac{100 \times 365 \times 5}{1{,}000} = 182.5 \text{ kilotons},$$

or in other words, that while the life of the one was double that of the other, the actual measure of endurance of each was the same. No other conclusion seems reasonable, and any requirement that the one should show no more wear or fatigue at the end of a stated period, say four years, would be obviously absurd. On the other hand, a guaranty requirement that a pavement of a given kind must withstand a stated number of kilotons of travel before repairs become necessary, would be rational and general, regardless of whether the street is one of heavy or of light travel.

In the comparison made above, the roadways were assumed to be of equal width. It is obvious that if one of them were 30 ft. wide and the other 60 ft. wide, any unit of surface in the one would be subjected to a greater quantity of travel than in the other. Consequently, for purposes of comparison, the width of the roadway must be taken into account. We may do this by referring the quantity of travel to a unit of width of street, or of area of its surface. For this purpose the unit used may be considered either linear or square—that is, the quantity of travel per linear yard of width of the street is the same as per square yard of pavement surface. The square yard is the unit commonly applied to pavement areas. It is a convenient unit for application to determinations of density of travel, and its adoption for the purpose is suggested.

It is true that the travel is never evenly distributed over the whole width of the pavement. Its tendency is to concentrate on the middle of the street and this tendency becomes greater as the width of the street increases and as the quantity of travel decreases, so that no fixed rule can be stated that will apply to all streets. Upon a leading shopping street in a Western city, without car tracks, where the roadway is 34 ft. wide, and the travel unusually heavy, it was found that fully two-thirds of the whole travel was confined to the middle half of the roadway. On wide roadways where the travel is light, almost the whole of it will be found to use the middle half of the pavement only, while on crowded streets it may be quite evenly distributed over the whole surface.

In the absence of any fixed ratio between the quantity of travel on the several longitudinal zones of a pavement, we cannot do better, in forming general conclusions, than to consider the whole travel as distributed equally over the whole width of the pavement. It is quite practicable, in such special cases as are thought important, to determine with fair accuracy the relative quantity of travel on different zones, but for purposes of general comparison, one street with another, it is not usually essential.

The final reduction of volume or weight of travel should therefore be to kilotons per square yard Thus, if a pavement 36 ft. or 12 yds. wide carries a travel of 240 kilotons per year, we would say that the travel amounts to $\frac{240}{12} = 20$ kilotons per square yard per year.

It was stated above that the general proposition that the endurance of a pavement is measured by the aggregate weight of travel it carries is subject to some modifications. The more important of these are:

1. The condition in which the surface of the pavement is maintained. If two pavements, alike in all other respects, and subject to the same quantity of travel, are not kept equally clean, their relative endurance will be affected. A film or coating of street dirt acts as a cushion between the pavement and the wheels of vehicles and may be quite effective in reducing the wear and therefore the relative life of the pavement.

2. If a pavement be kept constantly wet, as by street sprinkling, it will be worn out more rapidly than if kept comparatively dry. A familiar illustration of this fact is afforded by the operation of sawing stone where the stone must be kept wet by a small stream of water in order to make the so-called saws effective. This consideration is of importance and deserves more attention than it usually receives. There can be no doubt that the practice of keeping the pavements unnecessarily flooded by sprinkling carts materially reduces the life of pavements of all kinds. The travel census should therefore state the surface condition of the pavement in order that due allowance for its effect may be made.

3. The *speed* of the travel over a pavement is undoubtedly an element of variation in the effect of that travel upon a pavement, but we are almost wholly without data upon the subject. It should, however, not be very difficult to determine approximately, by experiment, the influence of speed upon the destructive effect of travel. It is suggested to engineers that such experiments be undertaken. If, for instance, a horse with sharp shoes were caused to travel over a floor of soft pine plank at the speeds of walking, trotting and running, the relative impression in the soft wood, made by the horse's shoes, at the different speeds, could be approximately measured and determined More accurate methods can doubtless be devised for determining the effect of speed of both horses and vehicles and coefficients deduced therefrom, and these could be applied in order to equate the total travel where speed is observed and recorded, as it should be, in street censuses.

When, however, we attempt to actually apply any measure to the endurance of pavements, we meet with not a few practical difficulties and soon find that we must be content with approximate determinations. It would be preposterous to propose that all the travel over a street, during its life time, shall be counted and weighed accurately. How then may we arrive at a fair approximation to the facts, within reasonable limits of time and expense?

Undoubtedly the quantity of travel over any street varies more or less with the seasons of the year, and the aggregate may vary widely with different years. But if we could ascertain the quantity of travel per day over any street for a few days, at, say, two or three intelligently selected periods during the year, the results might be fairly used to compute the average travel per day during the year. If at the same time we divided the vehicles into certain classes, and ascertained the average weight of each class, we could determine with fair approximation to the truth the average tons of vehicles per day passing over the street. If a uniform system of counting and rating were adopted and applied to all streets alike, it would afford a comparative measure of the quantities of travel over each, even if the results were not strictly accurate.

The practical application of such a system is not so difficult as it may at first seem and the cost need not be very great. Such a system of censuses of travel was formulated by one of the large asphalt paving companies more than twelve years ago, and applied to more than a hundred streets in different cities, but, unfortunately, they could not be continued long enough (i. e., until the pavements were worn out), to yield the data they were intended to furnish. The experience proved, however, the feasibility and practical accuracy of such censuses of street travel.

III.

Censuses of Street Travel.

The object of a census of street travel upon any street is to determine the quantity of that travel, expressed in such terms as will permit of comparison with the quantity of travel on other streets in the same city, or in other cities.

Classification of Travel		6 A.M. to 7 A.M.	7 A.M. to 8 A.M.
Class A	Walk	IIII III	
	Trot		
	Speed		
Class B	Walk		
	Trot		
Class C	Walk		
	Trot		
Class D	Walk	III	
Class E	Walk		
Class F	Walk		
Class G			
Class H			

Fig. 1. Proposed Blank Form for Taking a Census of Street Travel.

As extreme accuracy in determining the weights of vehicles and horses is impracticable, it is necessary to adopt some system of classifying the various kinds of vehicles, and to assume approximate standards for the weight of each class, that will be sufficiently accurate for practical purposes.

It is necessary also to adopt uniform methods for counting the vehicles and horses, and convenient forms for use in recording them. It has been found by experience that one bright and quick observer can count and record all the travel upon a street where the number of vehicles passing both ways does not exceed 200 per hour. Where the number exceeds 200 it is generally necessary to have two observers, and in that case each should confine his attention to the travel in one direction only. An extra observer is usually necessary to relieve the regular observers while away at meals, etc.

The most desirable position for observation is a second-story front window near the middle of the block where the travel is to be observed, so selected that a clear view of the street can be had for a distance of at least 100 ft. in each direction,

and where the sun will not be too much in the eyes of the observer.

As the result of considerable experience in street census work the following classification of vehicles is recommended:

	Tons.
Class A. Passenger vehicles and light delivery wagons, assumed average weight	½
Class B. One and two-horse trucks or wagons empty or light loaded, assumed average weight	1
Class C. One and two-horse trucks full loaded, and three or more horse trucks unloaded, assumed weight	1½
Class D. Two-horse trucks heavily loaded, and three or more horse trucks full loaded, assumed weight	2
Class E. Heavy vehicles with loads over two tons, average weight	3
Class F. Unusually heavy loads and vehicles, average weight	4
Class G. Horses unattached to vehicles.	
Class H. Motor vehicles.	

The weight named for each is the assumed average weight of the class, in long tons. For designating the speed of the travel the terms walking, trotting and speeding or galloping, are convenient and readily understood. Each vehicle as it is observed to pass is recorded by a tally mark in the usual way (see form, Fig. 1).

For recording the number of horses each vehicle mark is regarded as recording alone one horse. Vehicles with more than one horse are designated by one or more dots directly over the vehicle mark; thus one dot means two horses, two dots, three horses, etc. A convenient form for original records is shown by Fig. 1, though any other form

Classification of Travel		Date..... Weather..... Ther 7 A.M..... Rainfall..... Long Tons of Travel	Average Long Tons of Travel for .....Days	Percentage of each Class
A	Walk			
	Trot			
	Speed			
	Total			
B	Walk			
	Trot			
	Total			
C	Walk			
	Trot			
	Total			
D	Walk			
E	Walk			
F	Walk			
G				
H				
	Totals			

Fig. 2. Proposed Blank for Summarizing Results of Street Travel Census.

may be substituted, if found more convenient. It will be readily understood. This original sheet should, in addition to its appropriate title, record the following data, appropriate blanks being provided therefor at each side of the title, or elsewhere, viz.:

Name of city.....
Name of street.....
Between ..... and ..... streets
Point of observation (House No.)
Width of street between curbs.....
Paved with .....
In ....condition
Condition as to cleanliness.....
Heavily sprinkled. (Yes or No.)
Date of observation..... ...
Weather .....
Temperature of air 8 a. m.....3 p. m.....
Rainfall 6 a. m. to 6 p. m.....

Each sheet should be certified correct and signed by the observer.

A second form is necessary upon which to condense the records, and this sheet may contain in parallel columns the records for the several days covered by the census on any one street. A convenient model is shown by Fig. 2. The computed weight of each class of travel is here recorded. The computation of the weights requires no explanation, except in the cases of horses and automobiles, for which no weight is assigned in the above schedule. In reference to these, some consideration seems appropriate. The average weight of a city horse is probably about 1,200 lbs. There is a well-founded belief that the travel of horses is much more destructive, ton for ton, than that of vehicles. We have, however, no reliable and accurate recorded data upon the subject, and the exact facts are difficult to obtain. My own observations have convinced me that on all varieties of pavement the destructive effect of the feet of horses is much greater than is generally believed.

In a large Western city where the street cars all converge around one square, some censuses of travel were taken when all the cars were operated by horse power, and both the number of vehicles and of street cars were recorded. As the street-car horses all traveled in one line, and the great number of cars compelled other vehicles to keep outside the track, opportunity was afforded to observe the relative wear of the pavement (a part of it granite block and a part of it asphalt) inside and outside the tracks. In another city where a heavy travel passes over a street not much wider than the gage of the vehicle wheels and where, therefore, the wheels and the horses passed over different zones of the sandstone block pavement, an opportunity was afforded to judge of the relative destructive effect of vehicle wheels and of horses' feet. From such observations (confined to visible effects only, as I had no means for accurate determinations), I concluded that the destructive effect upon a pavement of a ton of shod horses was at least double that of a ton of loaded vehicles. There seems to be good theoretical reasons for such a conclusion, but they will not be here discussed. In the absence of satisfactory data we shall not probably go far wrong if, in equating the weight of horses and vehicles in street census work, each horse be figured at one ton in weight.

In the matter of the effect of motor vehicles on pavements there are not only no data, but there has been no time for even casual observations. Most of these vehicles have rubber tires and must cause very little wear upon any pavement. Their weight varies within wide limits and cannot be judged with any degree of accuracy by the ordinary observer. If it is thought desirable to include their weights in the tonnage upon the street, we may, in the absence of better information, assume an equated weight of ½ ton for motor carriages and of 1½ tons for motor trucks, which is probably about one-half their actual average weight.

The two last columns on Form 2 should show respectively the average weight of each class of travel for the number of days covered by it, and the percentage each is of the whole. The percentage of the tonnage at each of the three different speeds should also be computed and recorded. As the quantity of travel upon a street will vary with different days, it is desirable that the census should extend over seven consecutive days in order to obtain a fair average.

Form 2 should have appropriate blanks for recording also the following data:

Name of city.....
Name of street .....
Point of observation.....
Width of street between curbs.....
Kind, character and condition of pavement.....
Names of original observers.....

And a summary of average results as follows:

Average travel per day in long tons.....
" per cent. of vehicles.....
" per cent. of horses.....
" per cent. of travel, walking.....
" per cent. of travel, trotting.....
" per cent. of travel, speeding.....
" total travel in long tons per square yard per day.

If two such censuses were taken on the same street during the year, say one in February and one in September, their mean would, in most cases at least, fairly represent the average travel for the year, though four censuses through the year would be better.

It is not, of course, claimed that the results of censuses thus taken would be accurate, but it may be fairly claimed that they would be approximately correct. The conditions to be met do not permit of scientific accuracy of observation, nor of observations continued throughout the year, or even a considerable part of it, without very great labor and cost.

In order to determine the endurance of the several kinds of pavement with reasonable accuracy, it would not, of course, be necessary to maintain censuses of travel upon all the paved streets of a city. A comparatively few well-selected examples of each kind of pavement would be quite sufficient. In fact the requisite data could be obtained from a single street in each of a few cities with a comparatively small expenditure of time and money by the following method: Let a street be selected having a large quantity of travel and subject to average conditions. Upon one or more blocks where the travel is continuous, let samples, not less than 100 ft. in length and occupying the whole width of the roadway, be constructed of the several kinds of pavement it is desired to test. After their completion let censuses be taken of the travel over the block at such intervals of time as would give a fair average during the year, and let these censuses be kept up until all the samples are practically worn out. During this time all the conditions should be recorded, and account kept of the quantity and cost of repairs made. Such a trial would in a few years yield very valuable data, and if a similar trial could be conducted in each of half a dozen or more cities, the average results might be accepted as furnishing a fair measure of the endurance of each kind of pavement.

Considering the comparatively inexpensive character of such a trial and the very great value of the information that might thus be obtained, it is surprising that some of our enterprising city engineers have not long ago carried out the plan.

In this connection attention may be called to the very common use of the word "traffic" where the word "travel" is more accurate and appropriate. The difference of meaning will be obvious at once when attention is called to it. Traffic means, primarily, trade or commerce. A street might be the locality of a large traffic without vehicular travel. Travel is the proper word to designate, in the technical sense, that operation of horses and vehicles over a street which produces wear and abrasion of the pavement. We should therefore speak of "Censuses of Travel" and not "Censuses of Traffic."

(To be continued.)

JOINT OPERATION OF A RAILWAY BY TWO COMPANIES.

One of the peculiar provisions of the bill for a new transcontinental railway which is now before the Canadian parliament is that the line will be regarded as a common highway, open to any Canadian railway which may wish to use it, subject, of course, to certain regulations. This is referred to in the article on this railway elsewhere in this issue, and it is there stated that an example of joint operation is afforded by the Buffalo and Detroit Division of the Grand Trunk Ry., which is operated jointly by the Grand Trunk Ry. and the Wabash Ry. Information respecting this piece of line has been kindly furnished us by Mr. A. E. Robbins, Superintendent of the Wabash Ry., at Buffalo, N. Y.

This Air-Line Division of the Grand Trunk Ry., from Detroit to Suspension Bridge, 230 miles, has been operated for three or four years by passenger and freight trains of both the Grand Trunk Ry. and the Wabash Ry. This division is set aside from the other parts of the Grand Trunk Ry. system, with a joint superintendent and corps of dispatchers to handle trains on this division only. The joint superintendent has charge of the bridge and road departments and maintenance of the property, subject to the approval of the Wabash and Grand Trunk managements as to improvements and betterments. He handles all Wabash Ry. business as directed by the Superintendent of the Wabash Ry., and Grand Trunk business as directed by the Superintendent of the Grand Trunk Ry. All employees in the road, bridge, car and shop departments, and all agents, operators, clerks, yardmen, etc., are joint employees. All expenses for the maintenance and wages of these employees are divided and paid for on the basis of the number of cars and engines of each road handled over the Joint Section, the Wabash Ry. paying its own train and other necessary employees direct, and the Grand Trunk Ry. caring for its employees in the same way.

Both companies handle through freight trains

over the division. The local business between stations on the joint section is "joint" business, handled on a joint local train by joint employees, under the control of the joint superintendent, on joint billing, both companies participating in the revenue. The through freight trains and all passenger trains are manned by the employees of the respective companies. Wabash Ry. through freight is handled on Wabash billing, the same as on other parts of the Wabash system. Both roads handle local passenger business, retaining the revenue for all such business handled on their respective trains.

Ticket agents, as well as all other joint employees, are paid by the Grand Trunk Ry. on pay rolls of the joint superintendent, the expense of same being divided on the basis of the number of cars and engines of each road handled over the joint section. At Windsor, St. Thomas, Niagara Falls, Ont., and Fort Erie, Ont., the roundhouses, repair crews, and all warehouses and station houses on the section are operated jointly, the expense being divided as above.

A time card or schedule is issued by the superintendent of the joint division, governing all trains run over the division. There are approximately 50 freight trains and 17 passenger trains daily on the division.

Some further information on this matter is also furnished us by Mr. F. H. McGuigan, Manager, Grand Trunk Ry., and this we give below:

Both companies handle local as well as through freight. Shipments originating at and destined to points on the joint section are considered joint freight, from which both companies derive a revenue. Shipments originating at stations off the joint section and destined to points on the joint section, or shipments originating at stations on the joint section and destined to points off the joint section, belong to the company which secures the business, and that company receives all of the earnings.

The salaries of ticket agents, freight agents, clerks, yardmen, etc., are paid originally by the Grand Trunk Ry., and the Wabash Ry. is charged with its proportion on the basis of the number of cars handled for each company at the terminal, or over the section, where the expense is incurred. At the four points where roundhouses are located, which accommodate the engines of both companies, the expense of maintenance is divided in the same way as the expense for wages of agents, clerks, etc. Repairs to engines are charged to the company for which work is performed, each company paying for the maintenance of its own locomotives.

Between Windsor and Glencoe there are 17 passenger trains daily, in both directions, two wayfreights carrying passengers, and between 30 and 35 freight trains. Between Glencoe and Niagara Falls and Buffalo there are 21 passenger trains daily, in both directions, two wayfreights carrying passengers, and between 35 and 40 freight trains.

A NOVEL TYPE OF DRAWBRIDGE.

The Miami & Erie Canal Transportation Co., of Cincinnati, O., has a charter for operating the canal by electric towage, using trolley locomotives on a track along the towing path. At several points the track crosses the canal, and in order to make the curves as easy as possible the crossing is made by a skew bridge. At these points it was desired to build comparatively inexpensive bridges. The type of drawbridge adopted is pivoted at one end and has at the free end a bent supported by rollers running on a curved rail in the bed of the canal. The bridges were designed by Mr. Ward Baldwin, M. Am. Soc. C. E., Consulting Engineer, Mitchell Building, Cincinnati, and we are indebted to him for blue prints from which our drawings are prepared. The contractors for these bridges are Huston & Cleveland, of Columbus, O. The steel work was furnished and erected by the American Bridge Co.

The bridge shown in Fig. 1 is a plate-girder deck structure of 64-ft. span, with pile approaches and pivot pier. It has a swing of 30°, which is the angle at which it crosses the channel. The width of the canal here is about 45 ft., which is reduced to 22 ft. between the timber protection works. The girders, Fig. 2, are 48½ ins. deep, 7 ft. apart, and are connected by plate-girder cross frames and top and bottom laterals. At 3 ft. above the bottom chord is a shelf angle on the inside of each web, and on these rest the ties. The heels of the girders are connected by a semicircular drum girder, while two 15-in. I-beams are also fitted to carry the center bearing. The arrangement resembles a center-bearing railway turntable. Bearing rollers are placed under the drum. At the outer end of each girder is a post composed of four 5 x 3-in. Z-bars, the two posts being connected at the foot by 10-in. steel channels. The foot of each post has a shoe in which is pivoted a 12-in. roller, turned to a conical face, and riding on a curved steel 70-lb. rail. Outside this rail is a segmental rack, both rail and rack resting on plates 1 x 12 ins. bolted to a platform on the caps of piles driven into the bed of the canal. Knee braces are fitted between the posts and girders.

The operation is effected by a 5-HP. alternating-current 390-volt motor mounted between the girders at the outer end of the bridge and driving by gearing a pinion which engages with the rack on the bottom of the canal. With this, the bridge can be operated in about one minute. Hand gearing is also fitted to swing the bridge in case the motor should be disabled. The arrangement

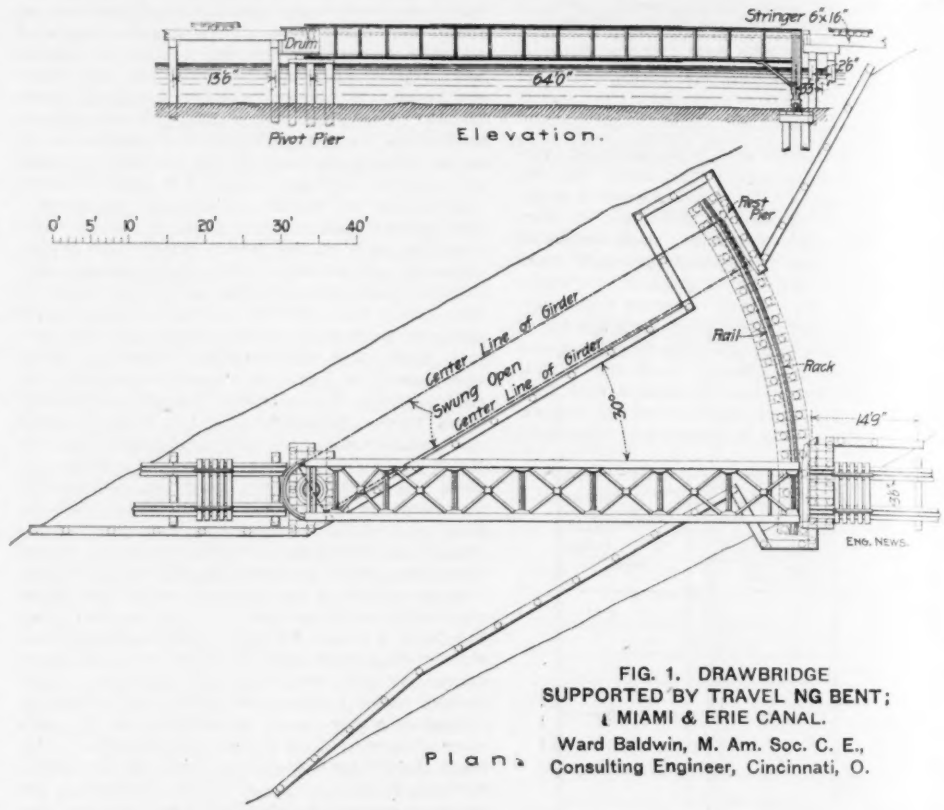


FIG. 1. DRAWBRIDGE SUPPORTED BY TRAVELING BENT; MIAMI & ERIE CANAL.
Ward Baldwin, M. Am. Soc. C. E., Consulting Engineer, Cincinnati, O.

shown in Fig. 3, and the proportions are as follows:

		Diameter, ins.	Pitch, ins.	Face, ins.
Motor pinion	A	2½	6	3
Spur wheel	B	24	6	3
Pinion	C	4	4	3
Spur wheel	D	20	4	3
Miter gears	E	12	4	2½
Rack pinion	F (12 teeth)	9 9-16	2½	..

The end latch, also shown in Fig. 3, is a horizontal bar operated by a solenoid or electro-magnet; the solenoid is bolted on the latch bar, and the plunger is bolted to the girder. The magnetic power withdraws the latch from the locked position. It is returned to this position by an elliptic spring, this spring having a reaction of 100% in excess of the weight of the moving parts of the latch. The electric motor also drives a small centrifugal pump supplying 1-in. jets for washing mud and silt from the rack and roller path. The motor and latch magnet are operated by switches on the shore, so placed that the motorman on the

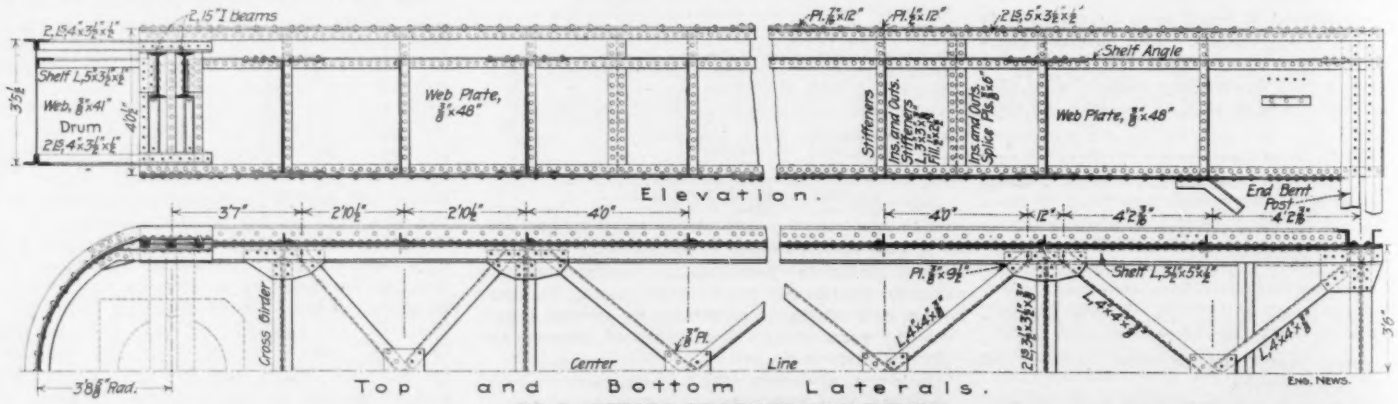


FIG. 2. DETAILS OF DRAWBRIDGE GIRDERS.

electric locomotive can turn them from his cab after crossing the bridge, and thus allow the boats he is hauling to pass through the draw.

The bridge weighs about 30 tons, and is designed for a rolling load of one 70-ton electric locomotive mounted on a pair of four-wheel trucks. The trucks have a wheelbase of 7 ft. and are 22 ft. c. to c., giving a total wheelbase of 29 ft. The weight on each axle is 35,000 lbs.

THE METHODS AND COST OF INSTALLING METERS AT CLEVELAND, O.

So far as we are aware, no city or water company in the world has even introduced water meters so rapidly as is now being done at Cleveland, O. From only 3,540 meters and elevator indicators in service at the close of 1901 the number had increased to 11,099 at the close of 1902, and to about 21,000 on Sept. 30, 1903. A large number of meters were in stock on the latter date, and it is expected that at least 4,000 more will be placed by the close of the present year. It is also expected that bids for 15,000 additional meters will be invited in February, 1904, and that within three years or so the 58,000 services now in use, with the new consumers meantime, will all be metered. The meters are being supplied and set by the city, without charge to consumers.

In our issues of Sept. 24 and Oct. 15, in the reports on the conventions of the Central States Water-Works Association, and the League of American Municipalities, respectively, some facts and figures regarding the installation of meters at Cleveland and the effect thereof on consumption were given. The information was taken from papers by Mr. Edward W. Bemis, Superintendent of the Cleveland Water-Works. Some further facts have been drawn from the second of the papers named, and from Mr. Bemis' annual report for 1902, and are presented herewith.

At the close of 1901 there were 55,130 services in use. Meters had been placed on nearly all the business premises in the city, except some small stores and saloons, but less than 500 residences had been metered, and all at the expense of the consumer. The distribution of the meters by sizes at the close of 1902 was as follows:

Size.	No.	Size.	No.	Size.	No.
6 ins.	11	2 ins.	310	⅝-in.	1,604
4 "	116	1½ "	394	⅝-in.	121
3 "	133	1 "	655	Elev. indicators	196
Total					3,540

Most of the meters set in 1902 and 1903 have been ⅝-in. The bulk of the meters placed in 1902 were from a lot purchased as the result of competitive bidding in December, 1901, the contract having been awarded to the Neptune Meter Co., of New York, as follows: 10,000 ⅝-in. at $6.75; 800 ¾-in. at $9.45; 200 1-in. at $13.50. A year later bids for 15,000 more ⅝-in. meters were invited and the contract was awarded to the same company, at $6.50 per meter, including connections or couplings, and a guarantee covering repairs for five years without charge.

On the subject of meter setting the following may be quoted from the second paper by Mr. Bemis, mentioned above:

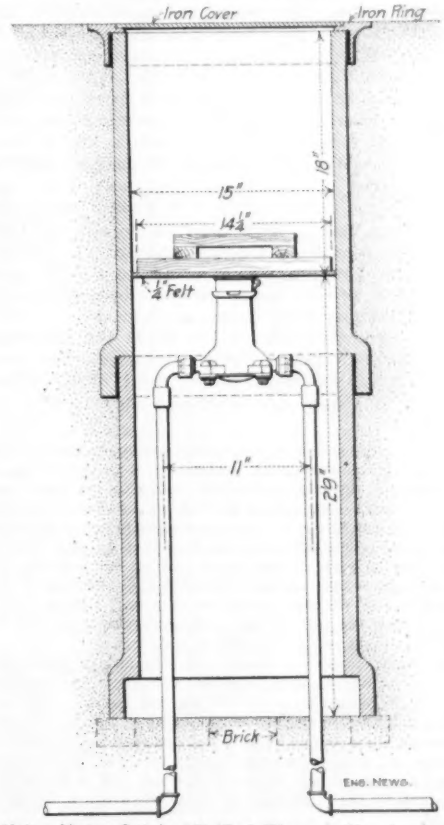
> At first, nearly all the small meters were set in basements; the others were set, as nearly all meters had been previously in Cleveland, in brick vaults at the curb. It was soon discovered that many houses had no basements or none convenient for meter setting. In other cases there were fears that the meters would be tampered with in the basements and sometimes there were difficulties in reaching those meters in order to read them, and hence a cheap but durable method of setting at the curb was sought for. This was at last found in an adaptation and improvement made by the meter department upon a method of sewer pipe setting in use in Watertown, Mass.

A cross-section of the meter box used at Cleveland is shown herewith, having been reproduced from Mr. Bemis' annual report for 1902. As to the cost of setting meters after the three plans, and particularly in the sewer pipe boxes, Mr. Bemis, in his report for 1902, says:

> The average cost of the 7,436 ⅝-in. meters set in 1902 was $5.41, while the meters themselves and the connections cost $6.75, or a total of $12.16.
>
> The average cost of setting the 5,752 meters that were set in basements was $3.92, and 974 in sewer pipe was $10.09, while the 710 set in brick vaults was $12.18. With respect to the cost of setting in basements of $3.92, $2.87 is for labor and $1.05 for material, as follows:

Brick	$0.17
Cement	.09
Wooden cover (not always used)	.33
Fittings	.46
Total	$1.05

The gang for basement setting is composed of from eight to ten men under a foreman. Half are meter installers at 27½ cts. an hour, and half laborers at 21 cts. per hour. These men work in pairs—an installer and a helper at each meter. Three men are used only where meters are set in brick vaults and a larger number than three are never employed except in the setting of 4-in. and 6-in. meters. The time required to set a meter in a basement varies from one to six hours, according to the rearrangement of plumbing that may be necessary and the other conditions in which the water services are found. The average time is from 4 to 4½ hours. No car fare is required, but a horse and wagon, which, with the driver, cost $3, provides all necessary transportation for the above mentioned gang of eight or ten men. The meter installers not only do all pipe fitting, but also all other work in connection with the installation of the meter, such as laying brick, putting on the wooden cover and repairing cement vaults.



Water Meter Set in Vitrified Pipe at Cleveland, O.

The cost (for material.—Ed.) of setting meters in sewer pipe has been as follows during 1902:

Manhole ring and cover	$2.07
4 ft. 15-in. sewer pipe	1.51
1 frost cover	.25
2 elbows	.10
2 couplings	.10
7 ft. ¾-in. pipe	.35
Total	$4.38

Of the items in this table the pipe is a variable quantity, depending on the depth of the service, and there are used in addition to the items enumerated from four to eight brick in each setting and usually a small quantity of cement.

A wooden frost cover 14¼ ins. in diameter, lined on the under side with quarter-inch saddler's felt, 16 ins. in diameter, and with a wooden handle on the upper side, rests on top of the meter.

For the first nine months of 1903 the cost of setting ⅝-in. meters after the three different plans, including material and labor, with the numbers set in each case, was as follows:

Method.	No.	Average cost—Setting.	Average cost—Meter and setting.
Basements	2,842	$3.99	$10.49
Sewer pipe	6,177	7.99	14.49
Brick vaults	621	9.21*	15.71*
Total and average	9,640	$6.84	$13.34

*Two meters were sometimes set in one vault.

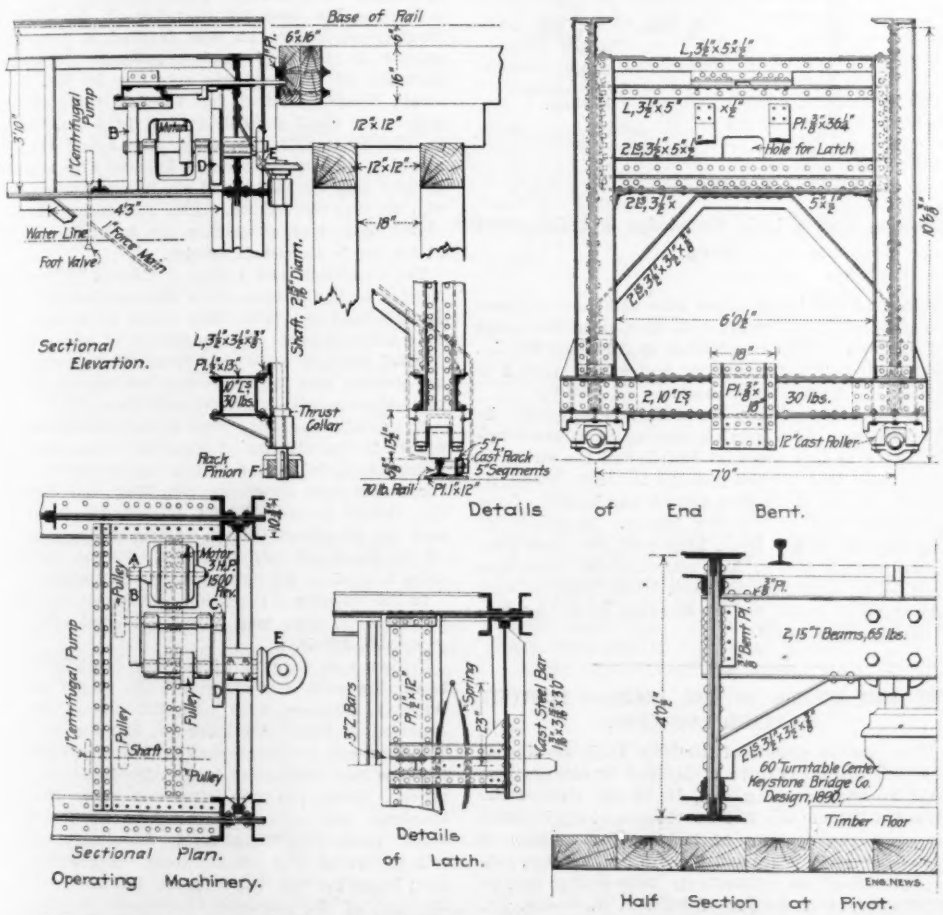


FIG. 3. TRAVELING BENT AND OPERATING MACHINERY OF DRAWBRIDGE FOR ELECTRIC TOWING LOCOMOTIVE.

The foregoing figures are from the paper read by Mr. Bemis at Baltimore, Oct. 8, as already mentioned. Some further statements from the same source may be given:

The meter rates are 5⅓ cts. per 1,000 gallons, regardless of the quautity used, but there is a variable scale of minimum charges for consumers with ⅝-in. meters, so graded as to be less than the flat, schedule, or assessment rate for the same premises. The lowest schedule rate is $3 per year, for a dwelling of three rooms or less, with an additional charge of 50 cts. for each room over three; $2 per bath room and $2 per water closet. There is no charge, under the schedule rates, for laundry or other extra faucets, nor for hose used to sprinkle lawns of less than 67 ft. width. The minimum meter charges are: $2,50 for premises whose schedule rates would be $1 or less a year; $4 where the maximum schedule rate would be $7; $6 where the latter would be $10; and $8 where it would be more than $10. Thus a house with six rooms, a water closet, bath tub, any number of extra faucets, and a lawn not over 66 ft. wide would be charged $8.50 a year under the assessment plan, and would pay a minimum meter charge of $6 a year. The latter (we may insert), with water at 5⅓ cts. per 1,000 gallons, would entitle the consumer to 112,500 gallons of water, which would be a little more than 300 gallons a day, or 60 gallons per capita for a family of five persons.

In conclusion, the author made the following statements regarding four obstacles that have confronted the water department of Cleveland since it began the wholesale introduction of meters:

1. The opposition of the master plumbers and to some extent of the journeymen plumbers also to the setting of the meters directly by the city and with the use of laborers at 21 cts., setters at 27½ cts., and foremen and inspectors at 42 cts. an hour, instead of plumbers at higher rates. This difficulty has been met by employing a plumber to wipe all lead joints and by the fact that the new meters have largely increased the business of the plumbers in the repair of house fixtures. Nearly all the pipes from the curb to the building, however, are of iron and so do not call for the aid of plumbers.

2. Some physicians feared that the meters would obstruct the flow of water sufficiently to cause the accumulation of disease-breeding filth at that point. This has been met by quoting the health records of metered and unmetered cities and of metered and unmetered consumers in Cleveland, and by showing that the reservoir of the meter does not hold a half teacupful of water and is constantly cleaned by the rapid flow of water whenever a faucet is used.

3. The third difficulty we have encountered has been the waste of water in the public school buildings, which by state law have hitherto secured their water free and so have been unmetered. We now plan to meter these schools and to see if we cannot legally prevent, by charge or otherwise, any use of water beyond such a daily amount per capita as the experience of cities that meter and charge for such use has shown to be reasonable.

4. The final difficulty, and the one still confronting us, is how to prevent waste in the numerous charities, which by state law are entitled to free water. All that we wish and in time hope to obtain is to fix upon some reasonable per capita use of water in every class of charities, as determined by the experience of cities where such places are metered; then we hope to meter them and charge for the use of water in excess of a fair per capita consumption. Thus the present temptation to waste the water that costs these charities nothing will be removed.

FAILURE OF A DERRICK AT LINCOLN, ILL.

An unusually high derrick, designed for use in erecting a court house at Lincoln, Ill., collapsed on Oct. 7, killing one man outright and seriously injuring two others. It is apparent from a consideration of the design of this derrick, as shown in Figs. 1 and 2, that its failure is hardly to be classed in the list of "accidents," since it could have been readily foretold by any one with an elementary knowledge of the stresses in framed structures. As seen in Fig. 1, a horizontal boom 85 ft. long, designed to carry a heavy trolley, was supported by four rods from the top of a mast 110 ft. high, which was in turn held by four guy ropes (not shown). This mast was trussed with two 1½-in. rods passing over a very short king-post. An approximate cross-section of the mast, which consisted of three sticks of timber, is shown in Fig. 2. Unfortunately the dimensions of these timbers have not been given in the sketches furnished to us, but in the report printed in a local newspaper the statement is made that the boom consisted of:

Heavy pine timbers measuring 14 × 16 ins., strongly spliced and reaching out 85 ft. from the upright part of the derrick. There were three uprights, each consisting of two large pieces of pine timber spliced together and securely bolted, all resting on a foundation of heavy timbers.

This same report goes on to state that the derrick collapsed when a load of only "400 lbs. was on the hook," and that this 400-lb. weight

was being carried simply for the purpose of lowering the hook when necessary. The derrick was constructed with a view to elevating four tons at a time and carrying a few hundred pounds, which was not at the end of the boom, could have contributed little or nothing to the event.

To any engineer who has even casually examined the design, Fig. 1, it is apparent that the cross-bending developed in the mast by the dead

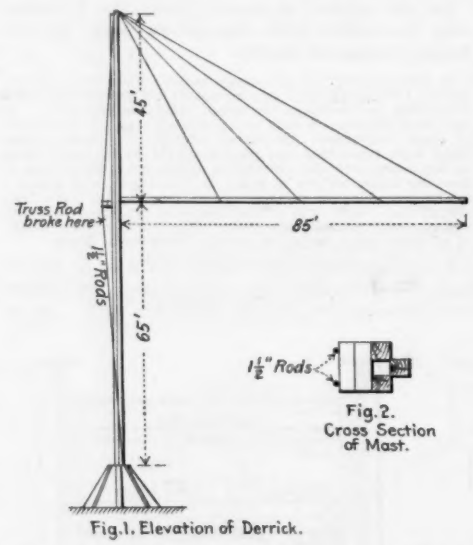


Fig. 2. Cross Section of Mast.

Fig. 1. Elevation of Derrick.

Showing That a Little Knowledge is a Dangerous Thing.

weight of the boom alone was sufficient to have strained the mast truss-rods almost to the point of rupture. When in addition to this load 400 lbs. was added, it furnished the last straw needed to break the back of the mast.

In our issue of Aug. 22, 1891, will be found the detail design of a derrick similar in general appearance to this one that failed, but the stress of that mast had a king-post 10 ft. deep, while, as shown in Fig. 2, in this derrick the length of the king-post was only a few inches. Moreover, in the derrick with a 10-ft. king-post the truss-rods had a section of 6 sq. ins., although the boom was only 52 ft. long and the mast 70 ft. high, so that the stresses would not be as great as in the derrick here illustrated.

THE 85TH MEETING OF THE AMERICAN INSTITUTE OF MINING ENGINEERS.

The opening session of the New York meeting of the American Institute of Mining Engineers was held Tuesday evening, Oct. 13, in the Hall of the Board of Education. The evening was largely taken up with the reading of biographical papers of members lately deceased. Mr. James Douglas, LL. D., presented an exceedingly interesting though brief account of the life of William E. Dodge. Dr. Leonard Waldo followed with an equally interesting biographical sketch of George S. Morison. The lifework of Prof. J. Peter Lesley was reviewed by Mr. Benjamin S. Lyman; and Dr. Thomas M. Drown, President of Lehigh University, presented a similar biographical sketch of Theodore D. Rand, late Treasurer of the Institute.

Following the reading of these biographical papers came an exhibition of telephoto pictures of mountain scenery by Mr. Dwight L. Elmendorf. These photographs are unique in that they were taken with a teleoscopic attachment to the camera, thus bringing out in striking relief every detail of scenery many miles away, so that the tinted negatives when projected upon a screen with a magic lantern give a remarkably fine effect.

The morning and afternoon meetings of the second day, Wednesday, were held in Schermerhorn Hall, Columbia University. After the welcoming address by Prof. Henry S. Munroe, the first technical paper of the session, on the Mineral Resources of British India, was read by Mr. S. C. Rudra, Madras Presidency, India. Mr. Rudra has the distinction of having been the first native citizen of British India to be educated as a mining engineer. His paper was not only full of interesting statements as to the mineral resources of India, but was interspersed with many humorous remarks and sketches of his personal experience. Mr. Rudra, in speaking of iron, said that almost every mountain in India was a body of iron ore, so widely is the metal distributed. In answer to a query, he spoke of his recent experiences in Corea, which is also a country of remarkable mineral resources.

The afternoon session was rather poorly attended, as many of the members visited the grounds and buildings of New York University, going in tally-ho coaches to University Heights. Not all the papers on ore deposits were in print, but abstracts were read from a few that were, and short discussions followed. Dr. R. W. Raymond emphasized the fact that the formation of crystals is a subject about which little is known, and that there are many as yet unexplained phenomena of crystalization. He believes that this is a most fertile field for investigators.

The session Tuesday morning, in the Hall of Mechanical Engineers, was devoted to discussing papers on steel and steel metallurgy. The most valuable of these papers was one by Mr. J. A. Capp, Tests of Steel for Electric Conductivity, which we shall publish in full in a later issue. In the discussion, Mr. Capp was asked whether nickel steel had been tested by him; and replying he said that he had tested steels containing about 3% Ni, but no others. The resistance of such nickel steel was altogether too great to make it fit for use in third-rail service.

The Condition and Action of Carbon in Iron and Steel was the subject of a speculative paper by Mr. Herbert E. Field, that called forth considerable discussion as to the theory of hardening.

Brief extracts were read from other papers, but the session was too short and the papers too numerous to receive much verbal discussion.

In the afternon trips were made to metallurgical plants in the vicinity of New York; the following establishments having kindly opened their works for inspection: American Smelting and Refining Co., Orford Copper Works, Nichols Chemical Co., and the Standard Oil Co. Through the courtesy of the President, Mr. Morris K. Jessup, members were invited to visit the new Stock Exchange.

In the evening a reception and dance was given at Sherry's, that was a well-attended and most enjoyable affair.

Friday was entirely given over to sight-seeing, beginning with a trip through the Rapid Transit Subway, between 34th and 42d streets, by the courtesy of Chief Engineer W. Barclay Parsons. Members met at the Murray Hill Hotel, where Mr. Parsons was introduced by Mr. Benjamin B. Lawrence. After the inspection of the subway, luncheon was served to members by the Engineers' Club, 374 Fifth Ave. Luncheon over, a trip by water was made around Manhattan Island; boats for this trip having been placed at the disposal of the General Committee by the Department of Docks and Ferries, the Street Cleaning Department, and the Cornell Steamboat Co.

The last technical paper of the session was presented Friday evening, at the American Museum of Natural History, by Mr. George F. Kunz and Mr. Charles Baskerville. The paper was entitled The Action of Radium, Roentgen Rays and Ultra Violet Light upon Minerals, and was illustrated by an exhibition of mineral specimens that were subjected to the action of radium and the "sparker." The fluorescence, as well as phos-

phorescence, of some of the minerals was remarkable, especially those from Franklin, N. J., and from Borax Lake. Mr. Kunz believes that since all the minerals from Borax Lake behave in the same manner, it is probable that they contain radium which was originally in the waters of the lake itself. This is a thought-compelling paper, and one well selected for the closing session.

Saturday morning the members and their guests, by courtesy of the Hudson River Day Line, were invited to go by boat to West Point. Although the day was foggy, the steamer was crowded on the trip up the river. A large number, however, returned by train, preferring to remain long enough to see the West Point-Harvard football game in the afternoon. The party was received at Memorial Hall, by Colonel Albert L. Mills, Commandant of West Point, and, after visiting the grounds and buildings, witnessed a review and inspection of the Battalion of Cadets.

Of the sessions at this, the 85th, meeting, it may be said that all were well attended, and at some sessions the attendance was unusually large. The great number of technical papers and their general excellence is also worthy of notice.

NOVEL METHOD OF ERECTION ADOPTED FOR THE FRANS BRIDGE AT VILLEFRANCHE OVER THE SOANE.

A new cantilever bridge was opened in August, 1902, connecting the city of Villefranche with the left bank of the River Soane. This bridge replaced an older suspension structure and consisted of two shore spans of 45.86 m. (150.4 ft.) and a channel span of 70 m. (229.6 ft.), carried on two masonry piers and shore abutments. Structurally, the bridge is of no particular importance, but the mode of procedure followed in its erection was sufficiently novel to deserve mention, and we describe it briefly from an illustrated description of the bridge published in "Annales des Ponts et Chaussees" for the first quarter of 1903.

FIG. 2. ROLLERS CARRIED BY HYDRAULIC JACKS USED IN LAUNCHING BRIDGE SPANS.

In erecting the two shore spans of the bridge the contractors feared to use falseworks on accout of the danger from floods. They, therefore, decided to erect each shore span practically complete on its respective bank of the river, and then to push it endwise out over the channel until its forward end rested on the adjacent river pier. The drawings of Figs. 1, 2 and 3 show the method of performing this operation.

The shore span complete, except for some of its secondary members and a part of its floor system, was erected on shore with each of its main girders resting on two sets of rollers. One set of rollers for each truss was located on the abutment and the other set was placed 15 m. (49.2 ft.) inshore. The arrangement is shown by Fig. 1. The construction of the sets of rollers was rather novel and elaborate, and it is shown by the drawings of Fig. 2. Each set consisted of two pairs of rollers staggered in plan, as shown by the drawing. Each pair of tandem rollers was held in a rigid I-beam frame, and this frame was supported on the plunger of a hydraulic jack. A hand pump connected with both pairs of rollers and provided for raising and lowering them by pumping water into the cylinders of the jacks. This facility of adjustment of the rollers allowed the load to be evenly distributed among them, and also provided against any undulating movement in launching the span because of the variation of the bottom chord from a true horizontal line.

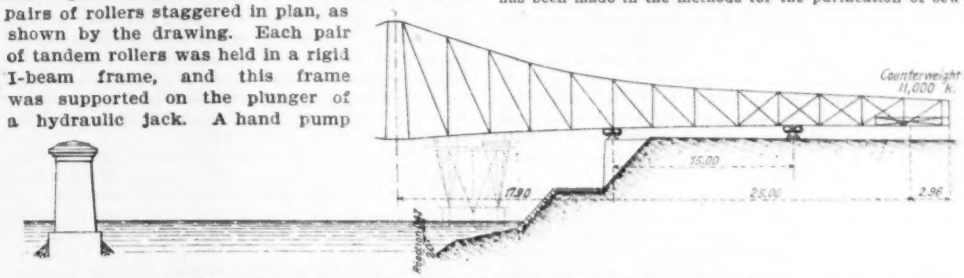


FIG. 1. FIRST POSITION OF BRIDGE SPAN ERECTED BY LAUNCHING ENDWISE FROM SHORE.

Fig. 1 shows the span mounted on the rollers ready for launching. It will be noted that the river end was erected overhanging the water, and that the shore end was counterbalanced. To launch the span a winch was placed on it and chains led to an anchor on the abutment. The spans were shoved forward a distance of 17 m. (55.76 ft.) for one and 79 m. (63.32 ft.) for the other, without any support for the outer ends. At these points a barge carrying a staging was floated under the overhanging end and the load taken by means of a hydraulic jack until the barge had settled so that its displacement balanced the weight, which was then taken by screw jacks. The span was then forced forward by the winders until the increased overhang made a second adjustment of the screw jacks necessary. This being accomplished by means of the hydraulic jack, the movement of the span was continued until its end rested on the pier, as shown by Fig. 3. The center span was erected by building outward from each pier in the usual manner.

About half a day was required for launching each span, and a day was selected when there was little or no wind. In launching one span the wind rose before its end was seated on the pier, and the swinging of the span which followed was so great that the engineers of the work state that, had the wind continued to increase, there would have been great danger of damage to the structure.

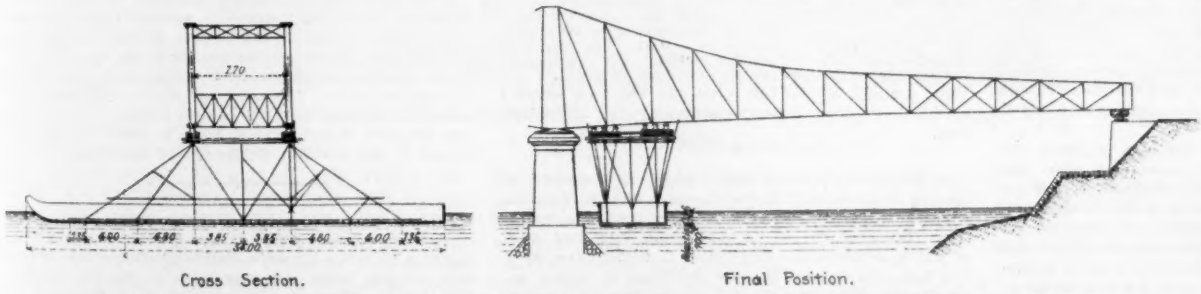


FIG. 3. FINAL POSITION OF BRIDGE SPAN ERECTED BY LAUNCHING ENDWISE FROM SHORE.

A BRITISH VIEW OF THE BACTERIAL TREATMENT OF SEWAGE.

By Dr. Samuel Rideal.†

During the last ten years, by careful study of the conditions under which bacteria resolve complex organic matter into simpler compounds, considerable progress has been made in the methods for the purification of sewage. At present no new breeds have been evolved for dealing with this problem, but man has attempted to control their action by modifying their environment so that the different chemical changes are, to a certain extent, kept distinct from one another, and a proper sequence in the progress of purification ensured. In the septic tank and its precursor—the cesspool—the environment is anaerobic, and permits of hydrolysis without oxidation. In bacteria beds, filters, and land, if sufficiently porous, oxidation processes can take place so long as free atmospheric oxygen is supplied with the food material to the aerobic organisms. Practically every kind of organic matter naturally occurring in sewage requires a preliminary hydrolysis before its oxidation can take place in water. Formerly, by chemical precipitation, this preliminary was shirked, and the organic sludge had subsequently to be dealt with. The anaerobic preliminary obviously reduces the amount of sludge, but at the same time, by rendering the organic matter gaseous and soluble, makes it essential that safeguards from aerial nuisance, and that adequate oxidation of the effluent should be secured.

The tank in which the hydrolysis takes place should be sufficiently large to ensure subsidence during a storm flow, and not so large as to allow the products of hydrolysis to accumulate and inhibit the action in dry weather. A grit chamber, capable of easy access for emptying, should precede the tank in all cases. Open tanks should be protected from the wind, as a quiet surface ensures the formation of scum, and aerial nuisance is minimized. In warm countries, with strong sewage and absence of storm water, such tanks should be closed with movable covers so as to form gasholders, and enable the gas to be utilized. Cement roofs are dangerous, as they are not air tight; the gases are wasted, and several explosions have resulted through negligence in several places where they have been erected. As hydrolyzed sewage smells very badly, the site for the tank must be carefully chosen, and the liquid must be brought quietly away from it without any exposed tumbling weirs or splashing. Attempts to deal with crude sewage without this preliminary treatment on contact beds have resulted in failure, and may be compared to an attempt to make beer and vinegar in the same vat.

I am strongly of opinion that the contact bed as usually designed at present represents only a temporary phase in the progress of our knowledge of sewage purification. It has already been recognized that it is fundamentally wrong to allow sludge to enter such beds, but few at present realize how wasteful it is to allow them to remain full for some hours with the liquid in contact with the material without air. If hydrolysis still proceeds during this time of contact, it could be done cheaper in the first tank; if an exchange of oxygen is taking place with the nitrates left in the empty bed, this reaction could equally well take place in the river, or even in a lagoon after the contact bed. Fineness of material adds considerably to the difficulties met with in working these contact beds, as it prevents the all-important entrance of abundant air. The more or less complicated types of automatic gear which have been designed

*Abstract of a paper read before the International Congress of Hygiene, at Brussels, September, 1903.

†Vice-President of the Society of Public Analysts, London.

for operating contact beds are as costly as a moving distributor, so that the advantage of economy or simplicity cannot be claimed for their use.

A considerable saving in cost of construction is also possible when the sewage is allowed to percolate through suitable material, as containing walls are then unnecessary. With large hard material there seems no reason to believe that any difficulties will subsequently arise. All problems of loss of capacity, cleaning, and renewal are done away with. It is important, however, to recollect, as I have already emphasized, that abundant air is essential for success, and that the best results are certainly obtained when the fall admits of the filter being built on the ground and not below it. Ten parts of NH_3 per 100,000 require 140 liters of air per 100 liters of sewage for complete oxidation—in other words, more air than liquids is necessary. Revolving sprinklers have been much improved and are now made to work with a very small head and with large beds can be driven automatically at little expense, whilst for small installations tippers or perforated plates can be employed.

As to the volume of sewage capable of being dealt with per unit of area, I believe that filters constructed in this way can deal with much larger quantities than contact beds, and I know of places in England where the delivery is 1,000 gallons per sq. yd. (2,500 liters per meter cube) 6 ft. deep with good average results.*

In the first place, I should like to point out that the effluent from a contact bed varies in quality throughout the whole period of discharge, but that from a continuous filter the analytical results are far more uniform. In the next place, it is also necessary to remember that the nitrates and the nitrites react with the unoxidized nitrogen in such effluents, as organisms of denitrification are normally present, and I prefer in all possible cases that the effluent should discharge into a lagoon or pond where this change can take place. In such lagoon light, air, algæ, and the higher forms of vegetation can all contribute to the final work of purification, and as no engineering skill and little cost in labor or materials is involved, the purification improvement effected by this means should never be omitted in any scheme from which the best results are expected.

It is exceedingly unfortuante that standards have been fixed in the past without any consideration of the local conditions, especially of the volume, aeration, and general state of the recipient stream. Some fixed distance below the outfall in mid-stream seems to be the proper place, in my opinion, from which samples should be taken. I am glad to find that arbitrary standards, based upon the albuminoid ammonia or the oxygen consumed figure, are being abandoned in favor of a standard of nonputrescibility or incubation.

CONCLUSIONS.—Modern practice in England and America supports the conclusions for which I contended in 1896, and which I may summarize as follows: (1) that tanks for the preliminary treatment, preferably bacterial and anaerobic, are essential for successful removal of fats from and production of ammonia in the sewage; (2) that percolating filters, with continuous admixture of air, are more economical and efficient than contact beds for the subsequent oxidations, including nitrification; (3) that denitrification finally improves the effuent, and that this part of the process is more rationally conducted in a lagoon or water-course than confused with the nitrifying process in expensive contact beds; (4) that it is impossible without enormous expense to sterilize the effluent of sewage works, and that it is more practical to purify drinking water, oysters, watercress, and the like, immediately before consumption.

ANNEALING AND CASE HARDENING TOOL STEEL.*

By E. A. Spaulding.

In annealing tool steel in small lots in an ordinary blacksmith's fire my method is to cut the steel to the desired length and heat it evenly and thoroughly to a good red heat, but not hot enough to scale it. The work is best done in a hollow or mound fire, which is made by packing wet coal on the fire until a good mound is formed, when an opening is made in front, of a size large enough to admit the steel that is to be annealed. Such a fire is practically an oven.

When the coal is well charred the steel is put in and heated up slowly and thoroughly, care being taken that it shall not get above a good red. The steel is then put in a bed of ground wood charcoal in a box to cool. My annealing box is made of cast iron, 4 ft. long, 15 ins. wide and 12 ins. deep. This is filled about two-thirds full of the charcoal dust. If quite small pieces are to be annealed, I heat them in an iron pipe 2½ ins. diameter, plugged at one end, the pieces being packed in with charcoal and all heated together. When thoroughly heated, the pipe, with its contents, is placed in the charcoal dust in the box to cool.

Small pieces if placed in cold charcoal, without the protection of the pipe, will come out imperfectly annealed and with more or less hard spots. I have used lime to some extent for cooling, but do not like it as well as coal dust, as it does not retain the heat as long. Some persons complain that cooling in lime puts hard "pins" and "streaks" in steel, but I do not think any trouble will arise on this score if the piece be large enough to heat up the lime; if, however, the piece is rather small it is better to heat it packed in a pipe and cool it as above mentioned. I have had very good results from this mode of treatment.

For case-hardening we use prussiate of potash, pulverized and mixed with fine salt, about equal parts. We heat the pieces to be hardened, apply the potash and immerse while it is flowing. I wish to emphasize this. Many smiths hold the piece until the potash is burned off. This is a mistake. It should be dipped while the potash is in a liquid state, as otherwise the piece will not come out as hard as it should. If we want a piece very hard we sometimes use cyanide of potassium, and heat in an ordinary forge fire, but this method is resorted to only when there are but a few pieces to be hardened.

We very often have pieces to harden, such as steps, centers, cups and tracers, which require to be soft on one end so that they can be riveted after hardening. For this purpose we use "Carburizer." The pieces are packed in a box made for the purpose, about 5 × 3 ins. x 1½ ins. deep.

A layer of carburizer is put in first; then the pieces are placed in the box, with the ends down that are to be hardened; the mixture is then filled in over and around the parts that are to be hardened, the quantity being proportioned, as nearly as possible, to the depth of hardening required, and the parts that are not to be hardened are covered with slaked lime.

The box is then placed in an idle forge and kept at a good heat for an hour or more according to the size of the work. At the end of the heat, before quenching, the fire is forced so that the pieces may be hardened on a rising heat; they are then dipped. If the operation has been properly done the pieces will be glass-hard where covered by the carburizer and soft where covered by the lime.

*About 5,800,000 U. S. gallons per acre.—Ed.

*From "Sparks From the Anvil."

A 42-IN. WOOD STAVE CONDUIT is to be built by the water department of Atlantic City, N. J., to connect the Absecon reservoir and pumping station, which are about two miles apart, and are now connected by an open canal. Inasmuch as a 30-in. steel force main from this same pumping station to the city was laid across the marshes in 1901, we requested Mr. Kenneth Allen, M. Am. Soc. C. E., Engineer and Superintendent of the waterworks, to inform us why wood was adopted in the present case. Mr. Allen states that wood was used partly for economy and partly on account of the experience with the 30-in. steel main. He also says:

We find the 30-in. main where uncovered in first-rate condition except as to the coating. This has become separated from the pipe and in places the pipe has been exposed to the salt water; and although such places as are discovered are cleaned and painted, it seems impossible to prevent serious corrosion within a comparatively short term of years. The contact with salt or brackish water makes the situation particularly unfavorable for steel pipe.

It is interesting to add that both Mr. W. C. Hawley, M. Am. Soc. C. E., who was Mr. Allen's immediate predecessor, and Mr. Emil Kuichling, M. Am. Soc. C. E., recommended wood instead of steel for the pipe line laid in 1901; but the city council decided to lay steel. The method employed in coating the steel pipe was described by Mr. Hawley in the annual report of the water commissioners for 1900-1, as follows:

Each pipe length was made up of five alternate inside and outside rings of ¼-in. steel, the diameter of the inside rings being 30 ins. and the total length of the pips being 28 ft. c. to c. of rivet holes. After riveting and calking the seams inside and outside, the pipe was heated, by a jet of natural gas burned inside, to a temperature of about 400° F., and then coated by dipping vertically in a bath of Mineral Rubber heated to the same temperature. The pipe was lifted out of the bath slowly so that the surplus coating material would run off, and it was then stood vertically inside a frame scaffold and immediately, while the coating was still hot and sticky, two strips of ten-ounce burlap, just wide enough to encircle the pipe and lap a few inches, were applied by a gang of paper hangers and brushed into the hot coating in the same way wall paper is brushed on to a wall. The laps were pasted down with hot coating material and, when cold, the pipe was loaded on the car ready for shipment.

The contract for the new wood pipe has been awarded to the C. P. Allen General Contracting Co., of Denver, Colo.

INTERSTATE WATER POLLUTION, as illustrated by the Hoosac River, with its drainage area lying in Vermont, Massachusetts and New York, is being carried on by the U. S. Geological Survey, in coöperation with Prof. Wm. P. Mason, of Rensselaer Polytechnic Institute, Troy, N. Y. The field work is being done by Mr. James R. Evans, under the direction of Mr. M. O. Leighton, Hydrographer-in-Charge of the Hydro-Economic Section of the U. S. Geological Survey. The sanitary status of the stream and the character of the study to be made are thus stated by the Survey:

This stream is, or should be, one of the most important, from the standard of natural resource, tributary to the Hudson; but it is at the present time badly damaged by refuse which enters it from North Adams and Williamstown, in the state of Massachusetts, and Bennington and smaller municipalities in the state of Vermont.

In addition to the periodical analyses which are made of samples of water taken from the river at chosen points between its source and its mouth, the character of the wastes discharged into the stream is being investigated and the approximate damage to the interests along the course of the river is the subject of computation. The condition as it crosses the boundary line of New York state from Massachusetts and Vermont is of particular importance to the riparian owners within New York state, and the river presents one of the clearest cases of interstate pollution which we have in the East.

THE MOST SERIOUS RAILWAY ACCIDENT of the week was a rear collision on a branch line of the Pennsylvania R. R. at Washington Crossing, near Trenton, N. J., on Oct. 17. A north-bound gravel train ran into the rear end of a repair train filled with laborers. At least 17 of the latter were killed, while many more were injured more or less severely. A heavy fog prevailed at the time of the accident. The repair train had stopped near a crossing for orders, and was, it is claimed, protected by a back flagman. The second train claims to have received no signal.——In addition to this accident, the record of train accidents for the week is made unusually bad by two wrecks, in each of which four lives were lost. One of these was a butting collision on the Southern Ry., near Keyesville, Va., on Oct. 19, while the other was the derailment of a freight train on the Missouri Pacific Ry., near Langley, Kan., on Oct. 15. The cause of either accident has not been reported.

LEGAL STEPS TO PREVENT POLLUTION of the Messalonskee River have been taken by the Maine Water Co., which owns the water-works supplying Waterville and Fairfield, Me. Some weeks ago the company sent letters to manufacturers and others on the river above its intake, warning them to stop polluting the stream. Satisfactory action not having followed the company has served legal notices on 33 alleged polluters of the river, including the city of Waterville. The attitude of the manufacturers as a class is doubtless expressed by a letter sent to the Maine Water Co. on Sept. 22, 1903, by the Dunn Edge Tool Co., of Oakland, Me. This company urges that

It has always been held that the great rivers of the country are the natural depositories for sewage and waste from dwellings, stores, mills, etc., and in using the Messalonskee for this purpose we are making the natural, proper and legitimate use of it. In fact we had been using it for that purpose many years prior to your occupancy and to your taking water therefrom for domestic purposes.

Continuing, the Dunn Co. argues that the prevention of contamination is impracticable; and that when the waterworks were built the river, "in the judgment of scientific men, was not a suitable source of water supply for domestic uses." Local feeling over this move of the Maine Water Co. runs high, both because of the attitude of the manufacturers and because the water-works are about to be appraised for purchase by a public water district.

A STEEL-FRAME BUILDING in course of erection at 56th St., near 11th Ave., in New York city, was blown over on Oct. 18, during a high wind. The frame consisted of steel columns and beams. Three bents of the frame, covering an area about 60 × 80 ft. in plan, had been carried up three stories in height, the girders being fitted up with erection bolts preliminary to riveting. The columns were merely set on their foundations, without anchor bolts, these latter not being required by the specifications. The building was being erected for the city of New York. The American Bridge Co. was the contractor for the steel work.

THE WABASH RY. CANTILEVER BRIDGE over the Monongahela River, at Pittsburg, Pa., which is at present in course of erection, was the scene of an accident on Oct. 19, in which ten or twelve workmen were killed. The traveler used for erecting the cantilever portion at the Pittsburg end of the bridge was wrecked and fell to the river below. Some of the portion already erected was carried down by the traveler and the whole wreckage fell upon two supply barges from which steel was being hoisted into place. The exact nature of the accident that caused the traveler to fall is not yet known. This bridge was described in our issue of Nov. 20, 1902. It is being erected by the American Bridge Co., of New York.

A FIRE IN A MILL BUILDING in South Boston was started in a peculiar way. It seems that a workman was pumping air into a kerosene tank that supplied four Welsbach burners, when the gage glass on the side of the tank burst. The spray of escaping oil is presumed to have been ignited either by a spark from an emery wheel grinding steel about 15 ft. from the tank, or it was raised to its ignition point by the heat from a box of oily iron turnings where spontaneous combustion may have been in progress. The oil tank itself did not burst, as it was found intact after the ruins were cleared away. These facts have been abstracted from a recent report of Inspector Macy S. Pope to the Boston Manufacturers Fire Insurance Co.